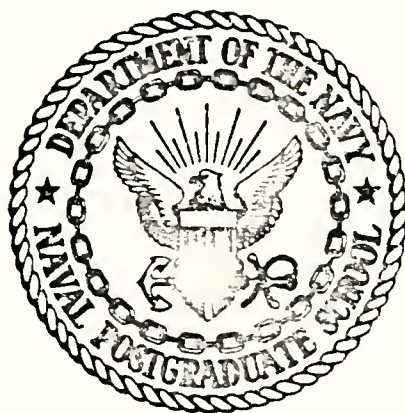# VALIDATION OF THE NONLINEAR SIX DEGREE OF FREEDOM MATHEMATICAL MODEL OF THE XR-3 CAPTURED AIR BUBBLE SURFACE EFFECT SHIP IN CALM WATER

George Thomas Forbes

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

VALIDATION OF THE NONLINEAR SIX DEGREE OF
FREEDOM MATHEMATICAL MODEL OF THE XR-3
CAPTURED AIR BUBBLE SURFACE EFFECT SHIP
IN CALM WATER

by

George Thomas Forbes
December 1974

Thesis Advisor: A. Gerba, Jr.

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Validation of the Nonlinear Six Degree of Freedom
Mathematical Model of the XR-3 Captured Air Bubble
Surface Effect Ship in Calm Water

by

George Thomas Forbes
Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1965

Submitted in partial fulfillment of the
requirements for the degree of

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from the

NAVAL POSTGRADUATE SCHOOL
December 1974

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LIST OF DRAWINGS

TABLE OF SYMBOLS AND ABBREVIATIONS

ac	alternating current
A-to-D	analog to digital
CAB	Captured Air Bubble
CG	Center of Gravity
₵	Center Line
db	decibels
dc	direct current
deg	degrees
D-to-A	digital to analog
FXPWAV	drag force in direction opposite to craft motion due to drag between pressurized air and water surface
g	gravitational acceleration
Hz	Hertz
kts	knots
lb	pounds
NPS	U.S. Naval Postgraduate School
NSRDC	Naval Ship Research and Development Center
RMS	Root Mean Square
psf	pounds per square foot
sq ft	square feet
ρ	density
δ	rudder angle
θ	pitch angle
ϕ	roll angle

ψ	yaw angle
plenum	cavity beneath the wet deck of the XR-3, formed by the sidewalls and the bow and stern seals, into which pressurized air is blown
hump speed	speed at which testcraft overcomes large low velocity drag and begins to operate on the cushion of cpatured pressurized air

ACKNOWLEDGEMENT

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I. INTRODUCTION

A. BACKGROUND

The Captured Air Bubble surface effect ship presents
a new concept in shipping for the surface force of the
U.S. Navy. Within a few years these vessels, supported
partially by a cushion of air and partially by the more
conventional hull buoyancy forces, will be joining the
Fleet. In preparation for that event it is of extreme
importance for detailed studies to be undertaken so that
the capabilities and limitations of such vessels may be
fully understood.

The term surface effect ship applies to a broad spec-
trum of different types of vessels. Among them are the
Air Cushion Vehicle (ACV), the Ground Effects Machine
(GEM), the Semi-Submerged Ship (SSS), the Captured Air
Bubble (CAB), and others. This study is concerned with
the CAB surface effect ship.

The Captured Air Bubble craft consists of two rigid
sidewalls which resemble catamaran hulls and flexible
seals between the water surface and hull structure across
the bow and stern of the craft. The enclosed volume is a
plenum chamber into which air is blown by a lift fan system.
The pressure in the plenum chamber acting over the area
of the plenum provides a lift force sufficient to support
a large proportion of the total craft weight. The remainder

of the supporting force is made up by conventional hydro-
dynamic forces acting on the sidewalls, plus some lift
forces due to the bow and stern seals and aerodynamic
lift at higher operating speeds.

In the "on bubble" mode of operation, at the higher
operating speeds, approximately two-thirds of the total
craft weight is supported by the air cushion, and therefore
relatively shallow sidewall immersion is required to support
the remaining weight. The shallow draft produces a lower
hydrodynamic drag and thus higher speed for a given power
than could be obtained for a displacement hull.

The XR-3 is a CAB surface effect ship of approximately
three tons displacement. The XR-3 was built by the Naval
Ship Research and Development Center (NSRDC) in 1966.
Following periods of testing by NSRDC, Annapolis Division
NSRDC, and Aerojet-General Corporation, the XR-3 was de-
livered to the Naval Postgraduate School (NPS), Monterey,
California in March 1970 for the investigation of basic
and advanced surface effect ship technology.

In addition to the XR-3 there exist other CAB test
craft. Among these are the Aerojet-General 100-A and the
Bell Aerospace Systems 100-B, both of approximately 100
tons displacement. These two vessels were constructed as
prototypes of a 2,000 ton ship. To date speeds in the 80-
knot range have been attained by these vessels.

Under a U.S. Government contract, Oceanics Incorp-
orated developed a digital computer simulation of the

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CAB ship loads and motions for the Surface Effect Ship Project Office (SESPO) in Washington D.C. This loads and motions program with the mathematical model of the Bell Aerospace Systems 100-B with six-degrees-of-freedom has been in use at the W.R. Church Computer Center at NPS since October 1972.

In December 1973, LCDR. D.G. Leo, USN and LT. R. Boncal, USN produced a mathematical model with six-degrees-of-freedom of the XR-3 test craft derived from the above-mentioned simulation model of the 100-B (Ref. 1). The modular construction of the 100-B simulation program facilitated the re-modeling of the program where necessary to fit the design differences between the 100-B and the XR-3.

B. OBJECTIVES

It is the objective of this thesis to validate the non-linear, six-degrees-of-freedom, mathematical model of the XR-3 CAB test craft in a comprehensive manner by direct comparison between instrument-measured variables on the XR-3 and computed variables produced by the simulation programs. In the process of carrying out this objective, subroutine modifications were made to the simulation program to improve on the structure of the simulation model and justification is given in the sections that follow for the changes that were made.

The data taken on the XR-3 measured in real-time, analog fashion using FM modulation was filtered, converted to

digital form, and processed in such a manner that it could be interfaced directly with the simulation program and a time history of true differences for each variable could be produced at each operating condition.

The present study is limited to operation of the test craft in calm water conditions at the test site located at Lake San Antonio Reservoir, California. The range of operation of the test craft includes:

1. Straight runs at various speeds with various locations of the center of gravity. The center of gravity was shifted by placement of two 125 pound water tanks at different locations on the deck of the test craft.

2. Straight runs at various speeds in an unladen condition.

3. Runs made at various speeds with various rudder angles applied to validate turning performance.

II. COLLECTION OF DATA

A. INSTRUMENTATION ON THE XR-3

In order to support the continuing studies being under-
taken at the Naval Postgraduate School on Captured Air
Bubble vessels, the XR-3 has been instrumented with devices
capable of measuring and recording time histories of many
different variables for later, post-run analysis (Ref.2).
The general configuration of the XR-3 is shown in Figure 1.
Table I shows a listing of the measurable parameters, the
range of measurement, and the accuracy with which the
measurements may be made. The locations of the measuring
instruments are shown in Table II. The measured data are
recorded on a Pemco Model 120-B magnetic tape recorder
which features 14 tracks for recording data and an edge
track for voice annotation during measurement runs. Each
of the 14 tracks on the tape recorder is capable of record-
ing $\pm$ 1 volt RMS with a tolerance of $\pm$ 0.5%.

B. POWER SUPPLIES

The tape recorder is powered from a 110 volt 60 cycle
auxiliary power unit, located on the aft weather deck as
shown in Figure 1., through a Pemco a.c. to d.c. converter
which provides a 26 volt d.c. power source. The three
accelerometers for measuring vertical, lateral, and fore-
and-aft accelerations are powered from a 12 volt storage
battery through a d.c. to d.c. converter which provides a
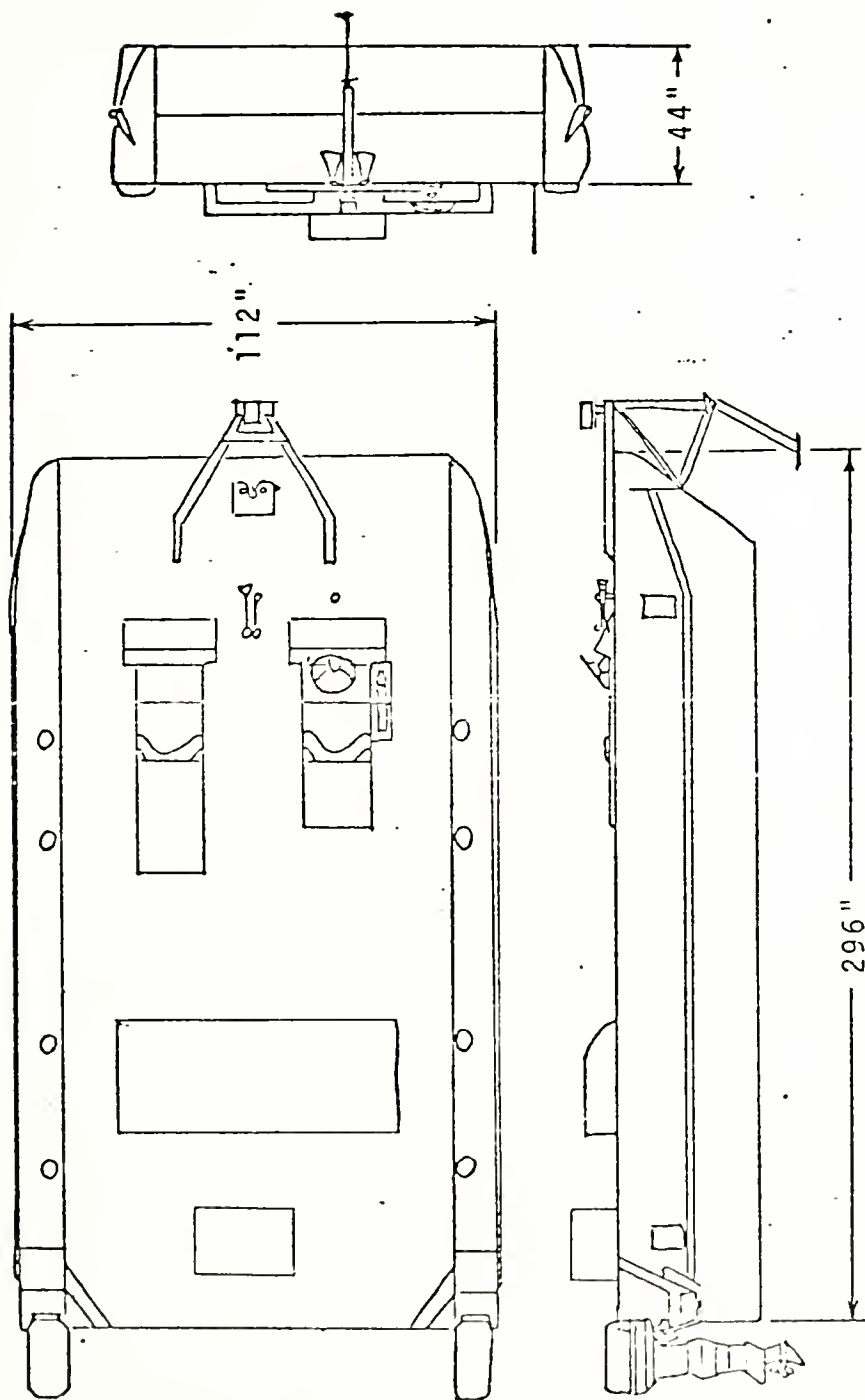
FIGURE 1. GENERAL CONFIGURATION OF XR-3

Table I. XR-3 Measurable Parameters

Parameter	Simulation Program Name	Range	Accuracy
Port Thrust	THSTP	0-500 lbs	$\pm$ 5 lb
Starboard Thrust	THSTS	0-500 lbs	$\pm$ 5 lb
Velocity	VEL	0-40 kts	$\pm$ 1 kt
Height	None*	$\pm$ 2 feet	$\pm$ 0.1in
Bowseal Press.	PBARB	0-60 psf	$\pm$ 0.5 psf
Plenum Press.	PBAR	0-60 psf	$\pm$ 0.5 psf
Sternseal Press.	PBARS	0-60 psf	$\pm$ 0.5 psf
Pitch Angle	THETAR	$\pm$ 15 degs	$\pm$ 0.5 deg
Roll Angle	DPHI	$\pm$ 15 degs	$\pm$ 0.5 deg
Yaw Angle	DPSI	$\pm$ 180 degs	$\pm$ 0.5 deg
Pitch Rate	PDEG	$\pm$30 degs/sec	$\pm$0.5 deg/sec
Roll Rate	QDEG	$\pm$30 degs/sec	$\pm$0.5 deg/sec
Yaw Rate	RDEG	$\pm$30 degs/sec	$\pm$0.5 deg/sec
Rudder Position	DELRS	$\pm$ 45 degs	not available
Longitudinal Acceleration	None	$\pm$ 0.2g units	not available
Lateral Acceleration	ACCLAT	$\pm$ 0.2g units	not available
Vertical Acceleration	ACCEL(3)	- 0.8 to +1.2g	not available

*Height is used to compute Draft as explained in text.

Table II. Location of Sensors

Sensor	Distance Forward of Transom	Distance from Center Line
Pressure Transducers		
Bow Seal	18'4"	₵
Plenum	12'4½"	₵
Stern Seal	1'6"	₵
Velocity	21'9" 4'9½" down from deck	₵
Height	24'1" 6" down from deck	₵
Gyros		
Pitch	12'6"	2'4½" Port
Roll	13'	2'4½" Port
Yaw	12'6"	2'4½" Port
Port Thrust	0	5'6" Port
Starboard Thrust	0	5'6" Starboard
Vertical Accelerometer	13'6½"	1'9½" Port
Lateral Accelerometer	13'6"	1'9" Port
Longitudinal Accelerometer	13'5½"	1'8½" Port

28 volt d.c. supply. The three gyros which measure pitch, roll, yaw, pitch rate, roll rate and yaw rate are powered by the 12 volt storage battery. The gyros also receive a 1 volt d.c. excitation signal from the 110 volt a.c. power supply fed through an a.c. to d.c. converter.

The height sensor mounted forward of the bow is powered directly from the 110 volt a.c. auxiliary power unit. The height measurement signal is converted to a ± 1.0 volt d.c. signal by a height sensor conditioner. The velocity probe, mounted on the same assembly as the height sensor, extends into the undisturbed water forward of the testcraft. The 28 volt d.c. power source for the velocity probe is the 12 volt battery through the d.c. to d.c. converter. The rudder position measurement is made by means of a load cell which receives a 12 volt d.c. supply from the battery.

The two load cells for measuring port and starboard thrust and the three pressure transducers for measuring bow seal, plenum, and stern seal pressures are all powered by a 28 volt d.c. supply from the 12 volt d.c. storage battery through the d.c. to d.c. converter. All five units also receive a 5 volt d.c. excitation signal from an amplifier-transducer package.

III. <u>DATA PROCESSING</u>

A. ANALOG TO DIGITAL CONVERSION

To provide measurements for validation of the mathe-matical model, data-gathering runs were made with the XR-3 testcraft on four different days at the Lake San Antonio, California test site. The data was recorded on magnetic tape using FM modulation, then processed into a suitable form for comparison with corresponding values computed in the XR-3 simulation program on the IBM 360/67 Digital Computer.

The data was converted from analog to digital form on an XDS-9300/CI-5000 hybrid computer at the NPS Computer Laboratory. From previous experience in data reduction by the XR-3 Research Group in the Aeronautical Engineering Department at NPS, it was found that filtering of the analog signal was required to remove unwanted high frequency noise from the recorded data. To provide this required filtering six Krohn-Hite digitally-tuned filters were assembled so that six tracks of recorded data could be processed simultaneously.

B. DESCRIPTION OF EQUIPMENT

The analog tape containing raw data from XR-3 test runs was mounted on a Honeywell Tape Recorder/Reproducer, Model 96 for playback. Connections were made through trunk lines to lead the output from the six selected tracks

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to the COMCOR CI-5000 Analog Computer as shown in Figure 2. Each channel of recorded data was then passed through an amplifier with a gain of 5 before being led out of the CI-5000 to one of the filters. The filters were operated in the low pass-maximally flat mode which provided a four-pole Butterworth response with an attenuation of 24db per octave from the cut off frequency. Cut off frequencies were set at 10 Hertz for all channels except port and starboard thrust which were set at 1.0 Hertz. Each signal at the output of its respective filter was led back into the CI-5000 for another amplification by a gain factor of ten. A Brush 8-Channel Recorder was also patched into the system at this point so that each of the six selected data tracks could be continuously monitored. Figure 2 shows the signal flow patch through the hybrid computer system for analog-to-digital conversion.

For analog-to-digital conversion, digital-to-analog conversion, and other applications, the CI-5000 Analog Computer and the XDS-9300 Digital Computer are interconnected through trunks. For A-to-D conversion in this application a sampling frequency of 200 Hz was chosen. In steady-state calm-water runs with the XR-3 none of the measured parameters can be expected to vary at frequencies greater than 10 Hz. Therefore, selection of a 200 Hz sampling frequency more than satisfies the requirements of the Sampling Theorem.
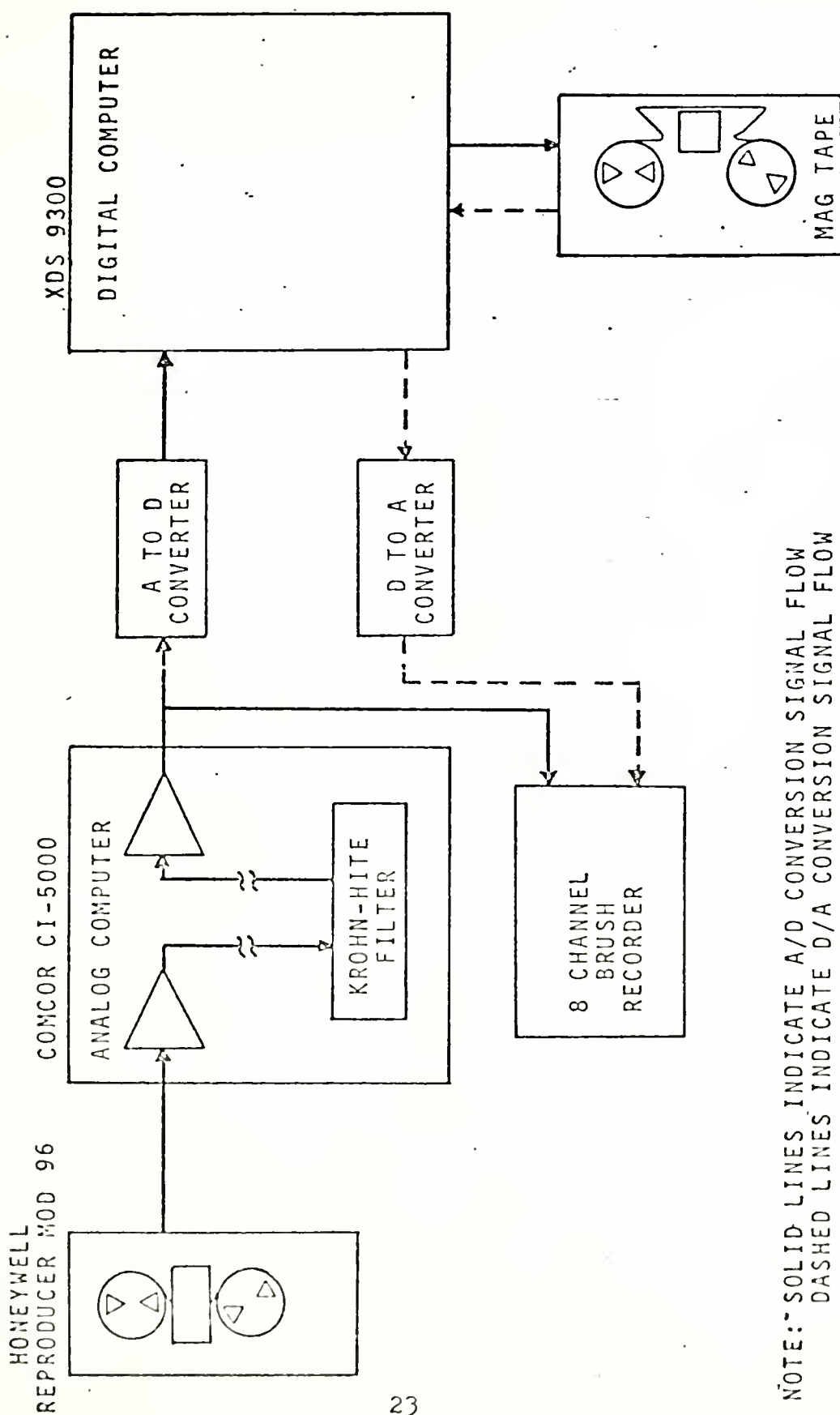
FIGURE 2. SIGNAL FLOW DURING ANALOG TO DIGITAL CONVERSION

NOTE: SOLID LINES INDICATE A/D CONVERSION SIGNAL FLOW
DASHED LINES INDICATE D/A CONVERSION SIGNAL FLOW

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The first step in the A-to-D process was to zero all possible bias errors in the system. Calibration steps are recorded on separate channel strips on the analog data tape which indicate zero and maximum signal readings for each sensor. Bias potentiometers at the input of the first stage amplifier on the CI-5000 were adjusted to properly zero all channels during the pre-test run calibration of the XR-3 sensors. Each signal was monitored on a digital voltmeter during the calibration procedure.

Execution of the FORTRAN program listed in Appendix A on the hybrid computer system enabled selective conversion from analog to digital form of specific time periods of analog data. Continuous monitoring of the voice edge track on the data tape provided a reference as to what the XR-3 conditions were at all times. After each file of data had been digitized and written on the digital magnetic tape, the tape was re-wound and that file most recently recorded was run through the digital-tc-analog conversion. The D-to-A signal was monitored on the Brush Recorder and compared with the analog signal to verify the validity of the conversion process. The finished product of the A-to-D conversion was a reel of 7-track digital tape consisting of many files of digital data. Each file on the tape contained a time history of six selected variables measured for a specific operating condition on the XR-3.

C. INTERFACE WITH IBM SYSTEM 360/67

Introduction of the 7-track tapes into IBM System 360/67 at the W.R. Church Computer Center at NPS entailed some further processing of data. In the XDS 9300 a binary number is represented by considering its octal representation, made up of 3-bit digits, whereas in the IBM 360 the same number is represented by hexadecimal, made up of 4-bit digits. As an example of this difference, a decimal number $(668)_{10}$ is $(1234)_7$ octal and $(29C)_{16}$ hexadecimal. It was necessary, then, to write a FORTRAN program to read each record in a file from the 7-track tape, make the conversion from octal to hexadecimal, store the data in hexadecimal form on a temporary storage disk, and to print out a portion of each record in decimal form. A listing of the program is included as Appendix B. The program uses the pre-compiled assembler language subroutine FORM to convert the data to its hexadecimal representation. Figure 3 shows the flow of information through the IBM System 360/67 computer in this validation.

The printed output from the conversion program is representative of the data in its original measurement form multiplied by a gain factor of 50 in the A-to-D conversion process. At this point in the process the numbers printed out were compared with the signals recorded on the Brush Recorder during A-to-D conversion to insure that the accuracy of the data had been preserved. This was indeed the case with the exception of some small amplitude,

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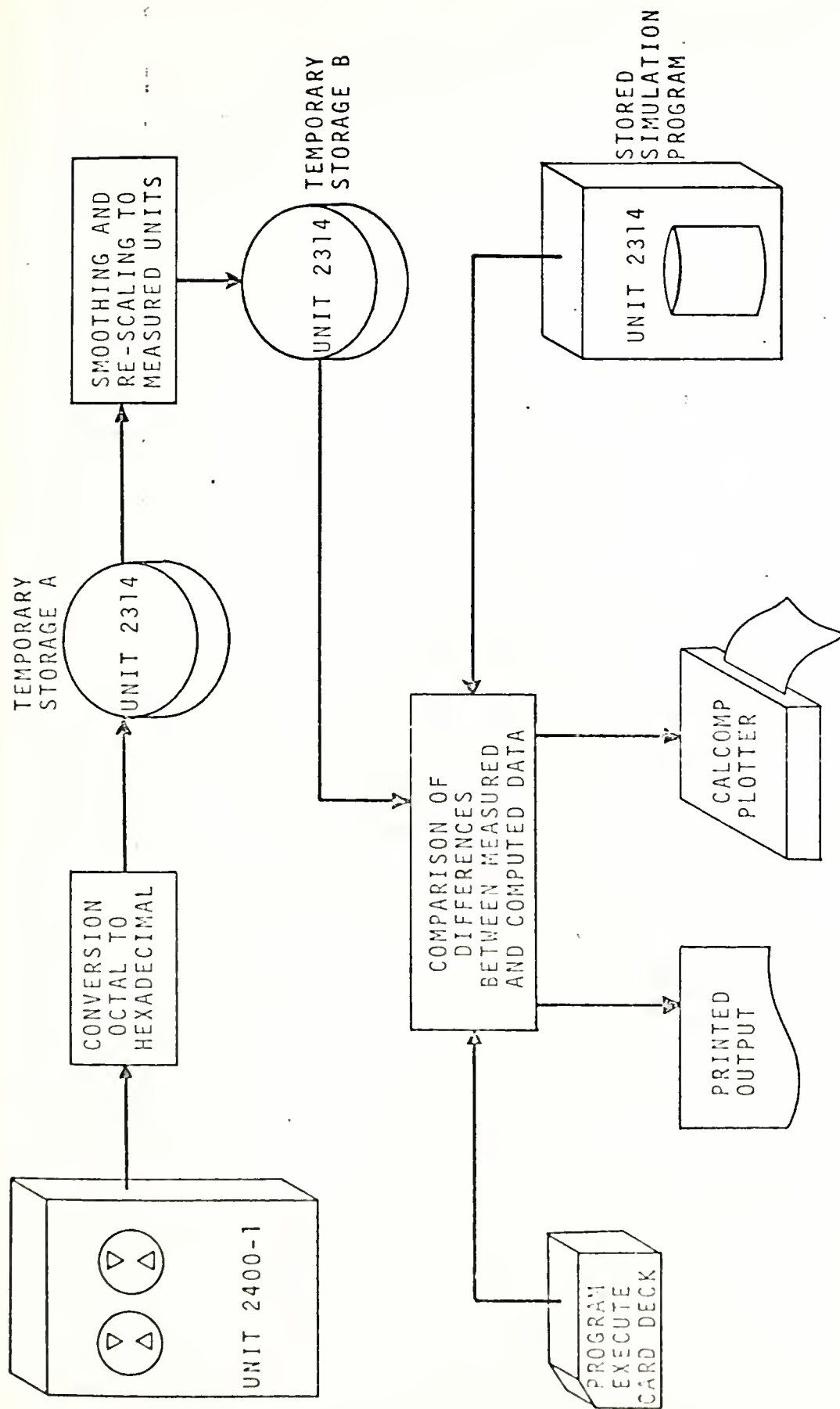
FIGURE 3. INFORMATION FLOW THROUGH IBM SYSTEM 360/67

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high-frequency fluctuations in the digitally reproduced data which did not appear to be present on the Brush Recorder tapes.

The final phase in data processing was to recover the measured data into the units which correspond with the measurement, i.e. pounds of thrust, degrees of pitch angle, knots of velocity, etc. to facilitate direct comparison in the XR-3 simulation model. To accomplish the recovery of data it was necessary to read the converted data from the temporary storage disk, multiply each set of variables by the inverse of the appropriate scale factor used when recording the data on the testcraft, divide out the gain factor of 50 introduced in the A-to-D process, and store the result on a temporary disk for later access by the XR-3 simulation program.

The height measurement made on the XR-3 during data collection runs does not have an immediately available counterpart in the XR-3 program as indicated in Table 1. A very close approximation to draft can be obtained from the height measurement through suitable scaling, however. The calculation of draft in the XR-3 simulation program is made with reference to draft at the center of gravity of the craft. The height measurement is made at a sensor located 191" forward of the reference center of gravity and 6.375" down from the deck level of the test craft (see Figure 1). The measurement of the height of the sensor above the surface of the water will vary as the

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craft pitches up and down at the bow. Since pitch angles

are, for the normal operating range, less than five degrees,

the small angle approximation may be made for the sine of

pitch angle. The draft measurement is synthesized by

solution of the following relationship:

$$DRAFT = SH + Z - HT + D*SIN\theta$$

where DRAFT = Water height above keel at the center of
gravity

SH = Height of sensor above CG = 7.145"

Z = Distance of CG above keel = 30.48"

HT = Measured height of sensor above water surface

D = Distance of height sensor forward of CG = 191"

$D*SIN\theta$ = Variation of measured height due to pitch angle.

A FORTRAN program was written to accomplish the process

of re-scaling to measured units and to provide the close

approximation to a draft measurement. A time index was also

included in the program to facilitate plotting each variable

versus time on a CALCOMP plotter. This feature proved to be

valuable as a final step in the process because each variable

could be closely examined in graphical form prior to acces-

sing the data by the XR-3 simulation program. It was at

this point in the procedure that some difficulties were

encountered in early attempts at signal processing, as

described in the following section.

D. FREQUENCY COMPONENTS ENCOUNTERED IN DATA

Examination of the CALCOMP plots of the digitally

reproduced measurement data revealed significant small

amplitude, high frequency noise impressed on the measurement signal. The noisy signal was not immediately evident on the Brush Recorder tape, however on close inspection it was apparent that some noise was passing through the filters. Figures 4,5,6, and 7 are representative CALCOMP plots of processed measurement data of thrust, pitch angle, velocity and plenum pressure respectively. These graphs are included to show the effect of noise on the processed data.

The source of noise present in the measurement data has not been established and can only be rationalized to be a combination of several possible environmental factors. First of these is vibration aboard the XR-3 testcraft from the twin engine propulsion system and fan drive system. Second, the testcraft is rarely run in completely glass-calm water conditions at the test site. Surface disturbances are nearly always present due to numerous pleasure craft, wind-induced ripples on the lake, and occasionally, the wake of the testcraft itself. Such disturbances can have a pronounced effect on the motion of the XR-3. Finally, 60-cycle power supply interference can be assumed to be present due to the antenna effect of unshielded wiring both in the testcraft and in the NPS Computer Laboratory.

1. Elimination of Unwanted High Frequencies

Recognizing that the noisy data rendered it all but unusable for any meaningful attempt at validation, methods were sought to eliminate the noise and to obtain a "clean"
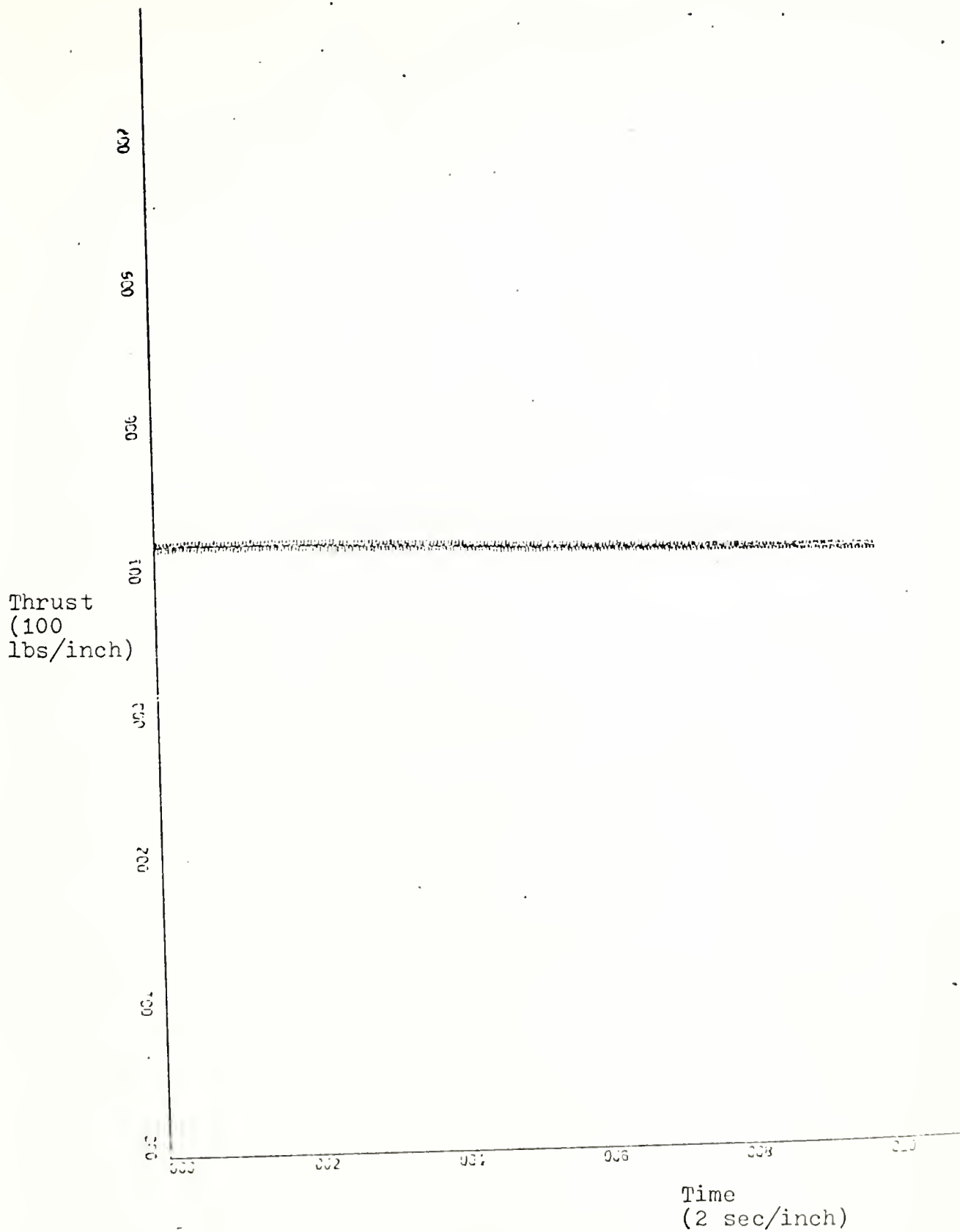
Figure 4. Plot of Thrust Vs. Time
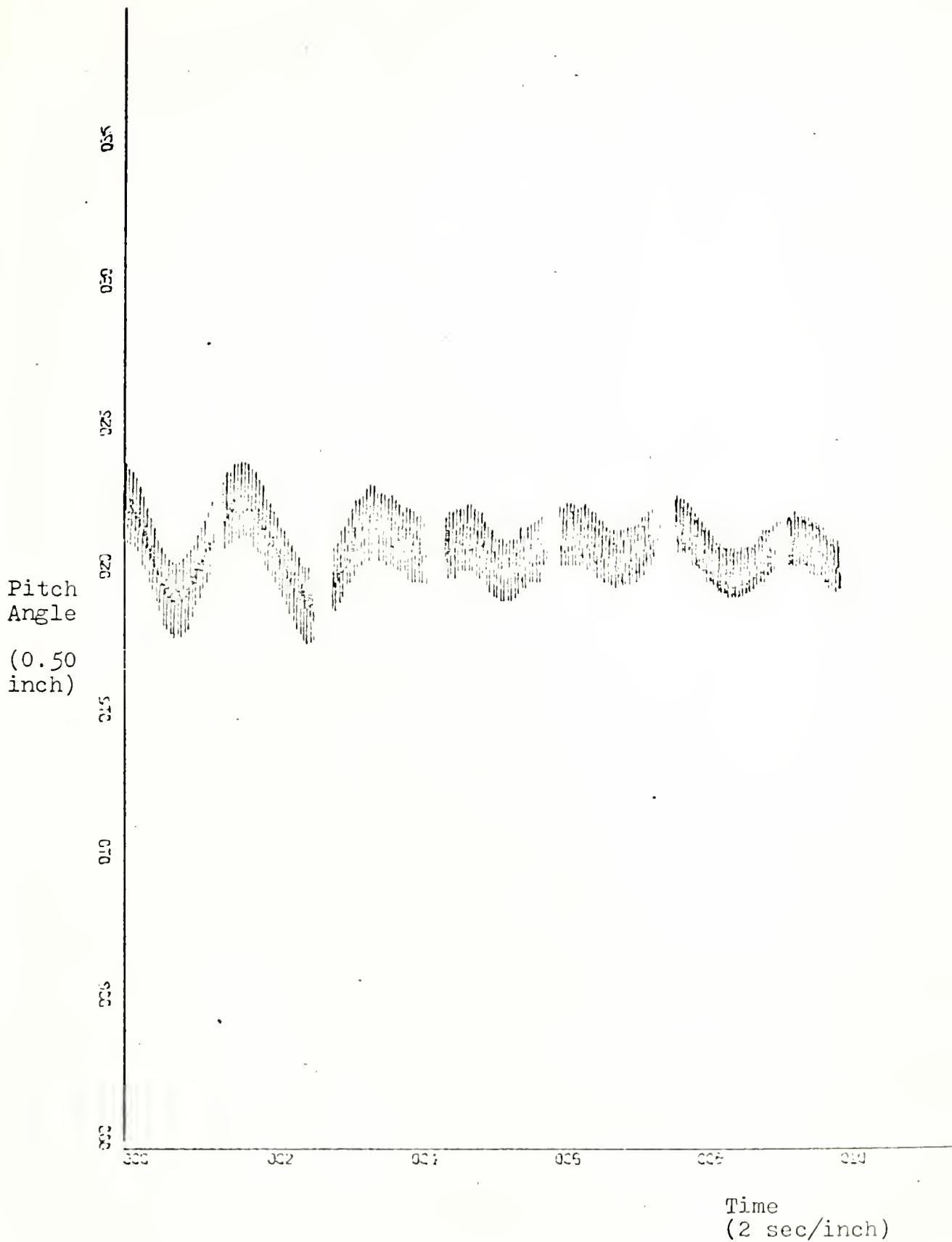
Figure 5. Plot of Pitch Angle Vs. Time

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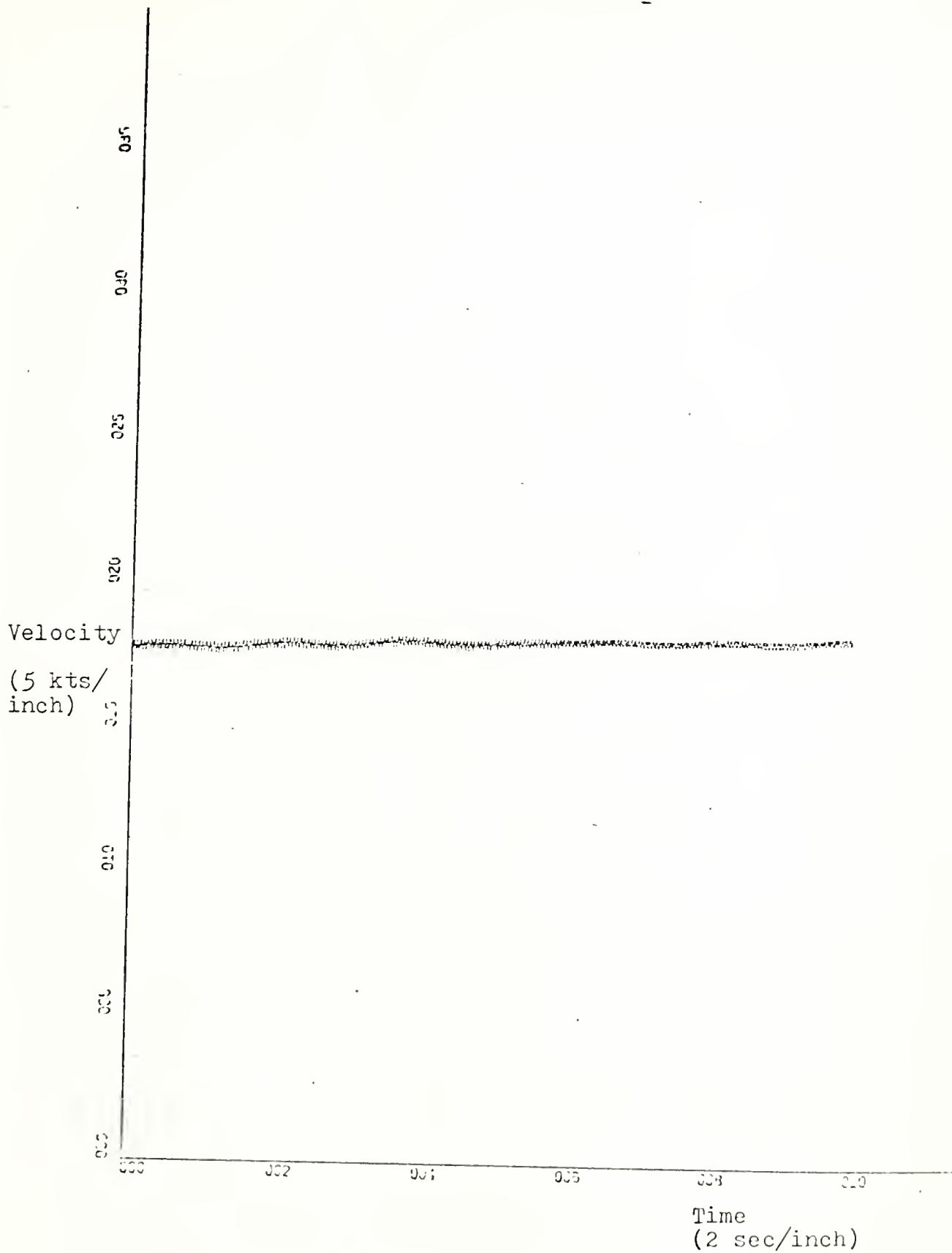
Figure 6. Plot of Velocity Vs. Time

32
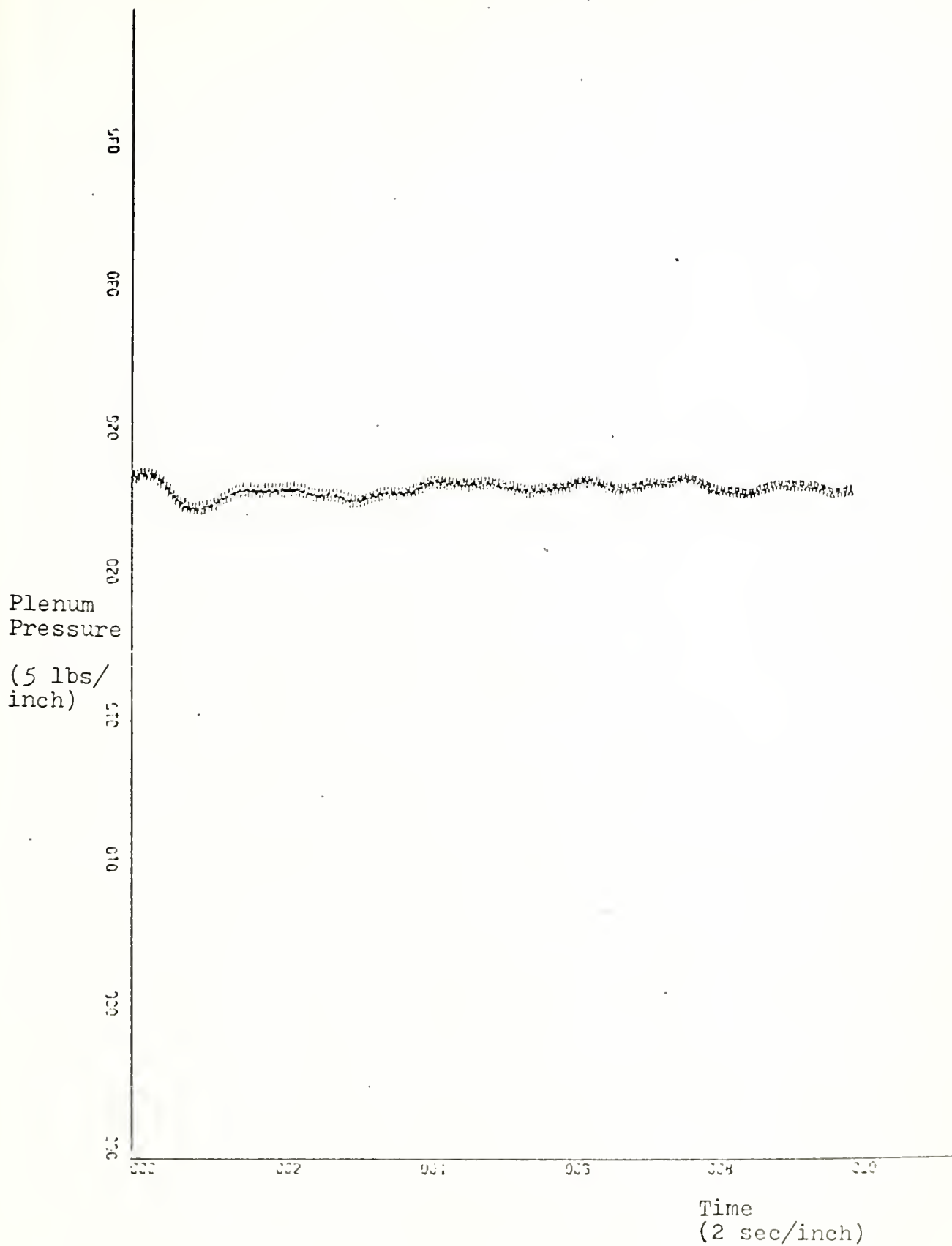
Figure 7.   Plot of Plenum Pressure Vs. Time

signal and, at the same time, to preserve the validity of
the actual measurement. The first effort was to filter
at a lower frequency. The result was displeasing for,
while the magnitude of the impressed noise was somewhat
reduced, lower frequency oscillations which represented
actual craft motions were nearly eliminated. The next
possible solution was to employ two filters in cascade,
thereby obtaining a low-pass filter with 48 db per octave
attenuation above the cut off frequency. This procedure
accomplished the main objective of removing virtually all
the noise and passing only signals representative of the
craft motions. The disadvantage of this method was that
only three instead of six measurements were now possible
because of the hardware limitations and synchronization
became an insurmountable problem.

The third possibility of removing the noise from
the measurement signal was to proceed on the assumption
that the noise was gaussian and white and to employ a
smoothing or time-averaging technique. The technique em-
ployed was to process the data as originally set forth and
then, in the final scaling process on the digital computer,
to obtain a moving time average. The algorithm implemented
on the digital computer was to calculate the sum of the
first ten points in the time history of a measured para-
meter, divide the sum by ten and call the resultant figure
the first point in the time history. Next, a counter was
incremented by five and the process was repeated to obtain

the next point. In this manner the data is reduced from 200 samples per second to 20 samples per second. The overlapping smoothing technique tends to preserve low frequencies. By comparison there were insignificant differences (less than two per cent) between this smoothing process and the aforementioned cascade filtering. The advantage realized was a more economical use of available equipment (filters) and a great savings in time required for data processing.

A listing of the program used for re-scaling the data to its original measurement form and including the smoothing routine is included as Appendix C. Figures 8, 9, 10 and 11 are CALCOMP plots of smoothed measurement data of thrust, pitch angle, velocity and plenum pressure respectively. By comparison with the measurement data plotted in Figures 4,5,6, and 7, it is evident that the moving time average smoothing technique has preserved the measurement information of value and has eliminated the impressed noise.

Thrust
(100 lbs inch)
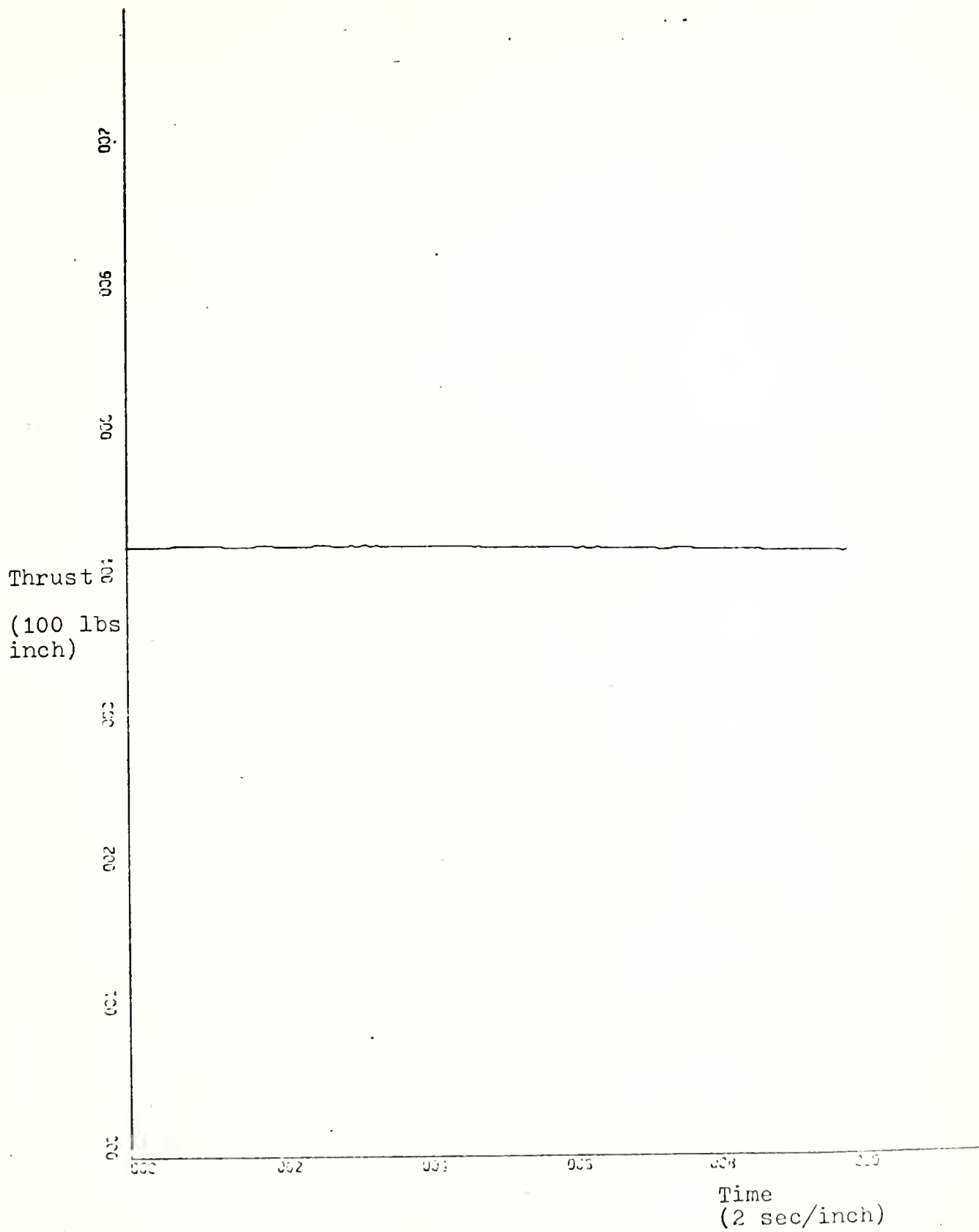
Time
(2 sec/inch)

Figure 8. Plot of Thrust Vs. Time After Smoothing

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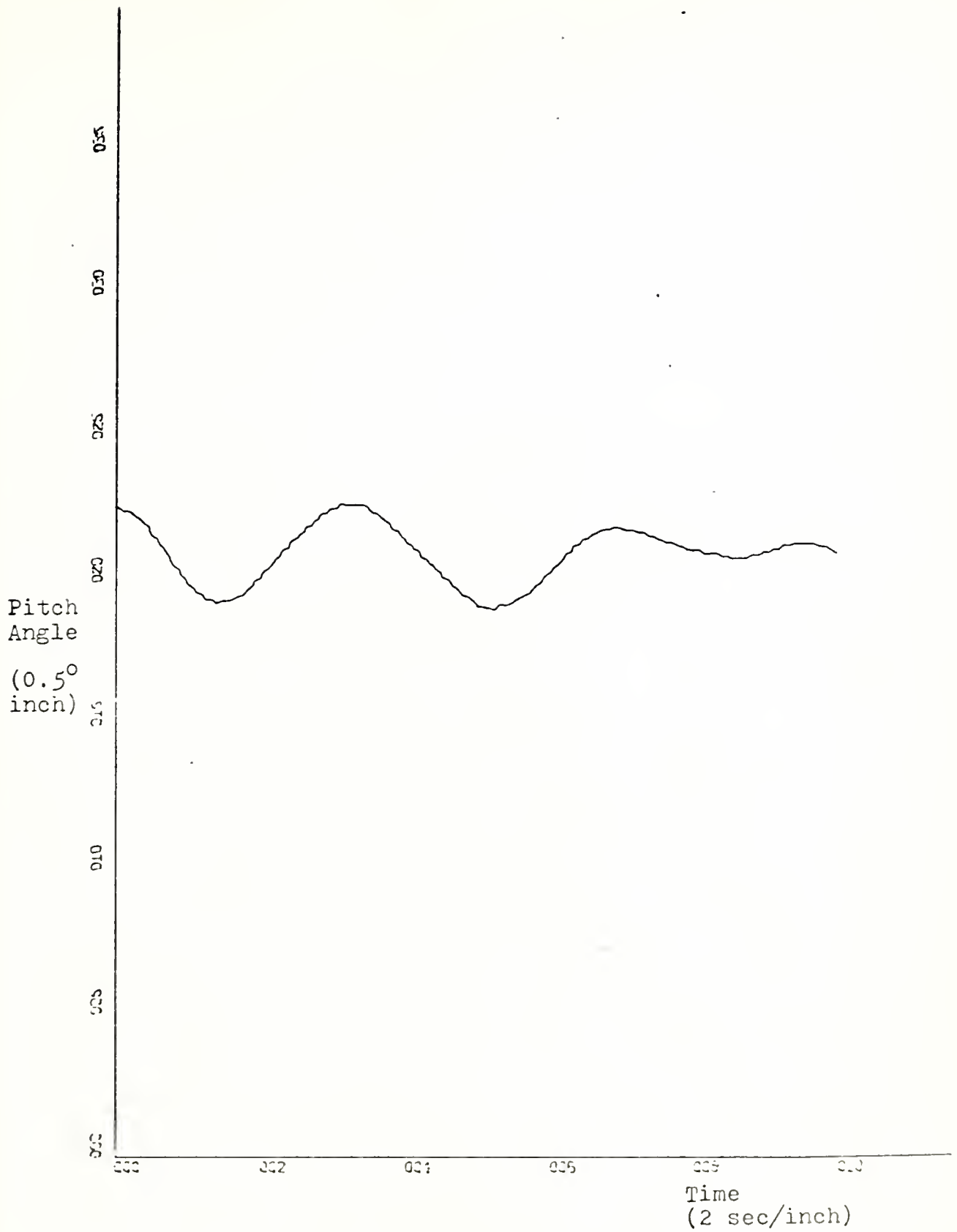
Figure 9. Plot of Pitch Angle Vs. Time After Smoothing

37
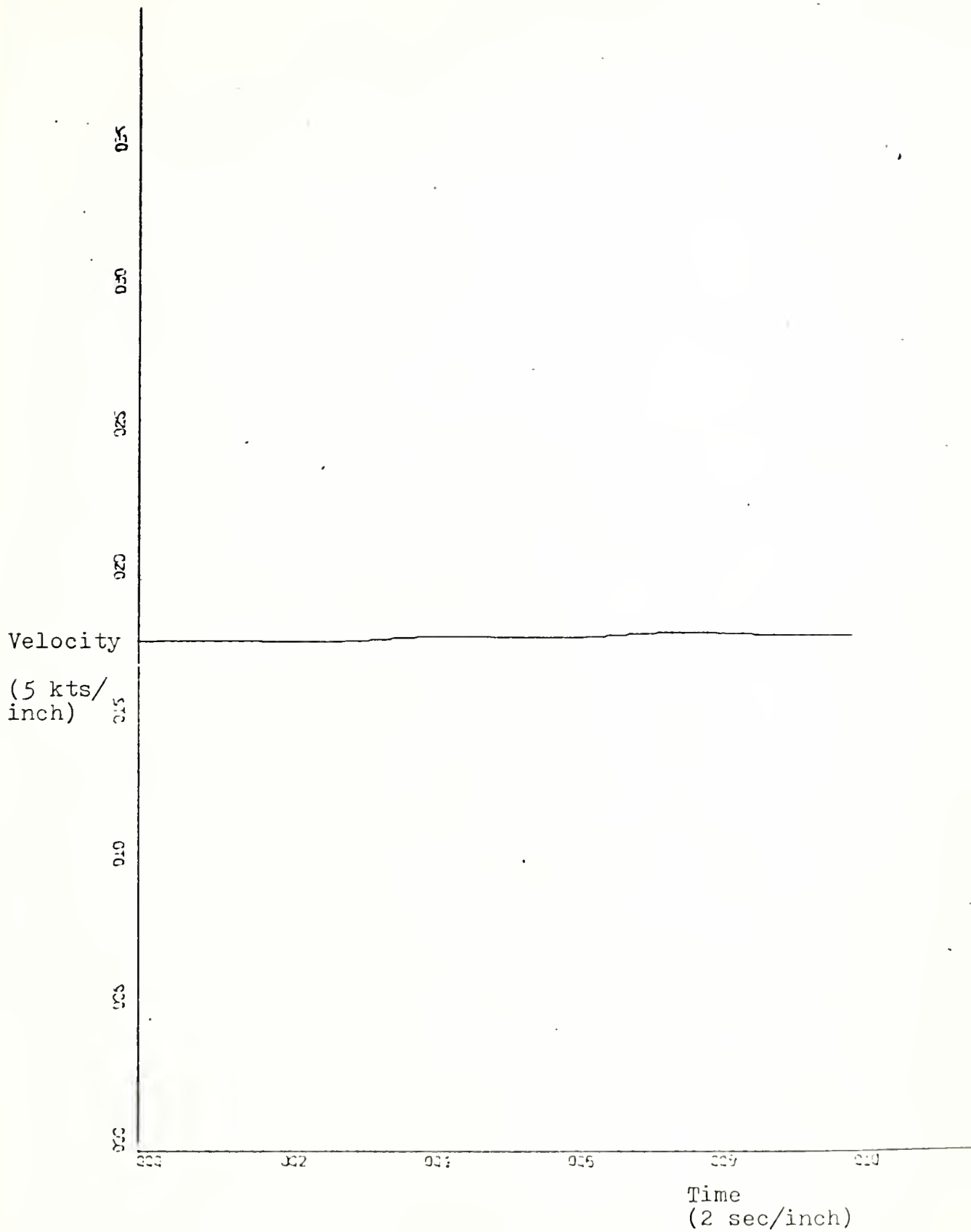
Figure 10.   Plot of Velocity Vs. Time After Smoothing

38
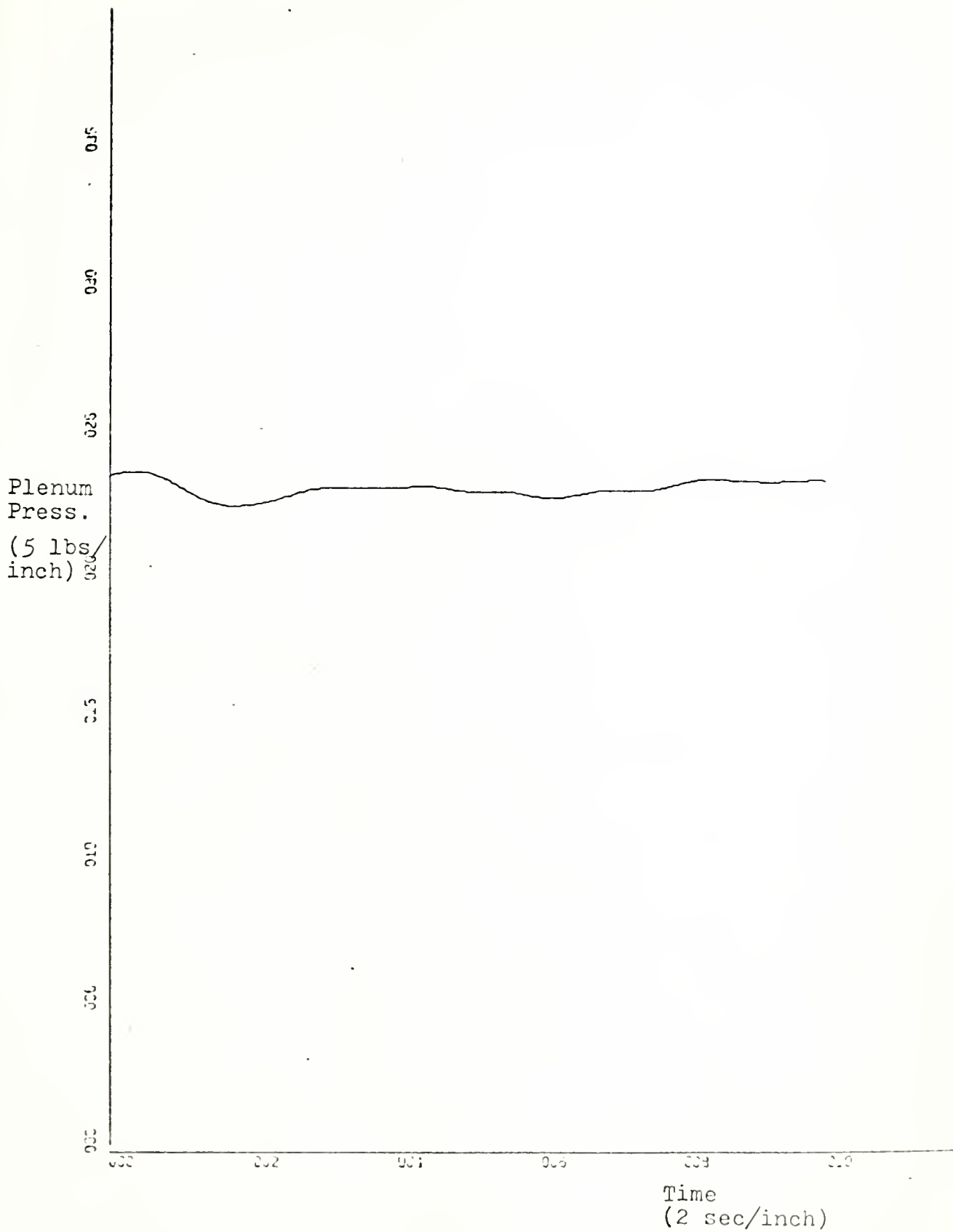
Figure 11. Plot of Plenum Pressure Vs. Time After Smoothing

IV. INTERFACE WITH XR-3 SIMULATION PROGRAM

A. LOGIC ADDITIONS TO SIMULATION PROGRAM

The XR-3 Loads and Motions simulation program was modified to the extent that, on execution of the program, the processed measurement data could be accessed if desired and on-line computation of differences could be made. The output from the program would then be a time history of the differences between computed and measured parameters. This entailed the addition of another option switch in the input data which is read by subroutine INCON. If the option switch is on or equal to one, subroutine INCON reads the measurement data into core from the disk where the data is stored. If the option switch is off or equal to zero, no reading of measurement data occurs.

It was decided to restrict validation or data comparison runs to ten seconds of simulation time because of core storage and computer time allocations. This decision set the size of the measurement data arrays at 200 elements. A COMMON block was added in subroutine INCON and RHS so that the measurement data could be available in subroutine RHS. As with other COMMON blocks, the feature to zero all elements of the added COMMON block was included in the main program. The following XR-3 test craft variables and the associated simulation names were selected for validation:

Total Thrust	THST
Velocity	VEL
Height	DRFT
Pitch Angle	THETAR
Roll Angle	DPHI
Plenum Pressure	PBAR
Yaw Angle	DEPSI
Rudder Angle	DELRS
Vertical Acceleration	ACCEL(3)
Yaw Rate	RDEG

The necessary logic was added in subroutine RHS such that the appropriate element with respect to time in the measurement array could be compared with the computed variable and a difference formed. The resultant differences were written into a temporary file for output by subroutine COLFIL after the simulation run reached the specified final time of ten seconds. Computation of differences was arranged such that positive values indicated that the computed parameter was greater than the measured parameter for any given sample time. The print interval for output purposes was set at one point every 0.05 seconds to correspond with the measurement data rate.

B. METHOD OF THRUST INPUT AND OBSERVED DIFFERENCES

The first step in the validation process was to initialize the mathematical model at a particular operating point with the expected trim conditions of velocity, pitch

angle, draft, and plenum pressure. The feature exists in the simulation program to provide a thrust map of up to 25 points. Additional logic was included to select every fourth point in the 200 element array of measurement thrust to be applied to the mathematical model as an input variable and a ten second simulation proceeded to produce computed velocity. All other measurement parameters except velocity were ignored during initialization runs. The difference between computed velocity and measured velocity was taken as an output from the model. Following initialization of the model, another computer simulation was made using computed thrust as necessary to hold velocity constant. All measurement data for the run was read in and differences between computed and measured parameters were taken as output from the computer model.

For validation studies using measurement data with very nearly constant thrust applied on the testcraft, the foregoing procedure could be shortened by including only the last phase. Provided that the initial trim conditions were known for input to the computer model, no loss of accuracy resulted in the process of validation.

C. METHOD OF RUDDER AND THRUST INPUT TO THE MODEL

Similar to the thrust map provision is a provision for a rudder map input to the computer model. Up to 25 points may be included in a rudder map and the necessary logic was included in the program to select every fourth

point in the 200 element array of measured rudder angle
for input to the mathematical model. The objective here
was to apply the same inputs to the mathematical model as
were used on the testcraft along with the initial trim
conditions for each case. This method proved to be of
little real value because a steering cable failure to the
port propulsion engine on the testcraft rendered the rudder
position measurement unreliable. To substitute for direct
steering control on the port engine, the starboard engine
was mechanically linked to the port engine by means of a
long, rigid bar. Thus, the starboard engine controls the
port engine in the rudder position and alignment of thrust
vectors on the testcraft. Virtually all precision in rudder
angle measurement is lost due to unavoidable play in the
linkage and lack of direct steering control over both
engines.

Validation studies involving turning maneuvers with
the XR-3 testcraft and the mathematical model were carried
out by matching yaw angles and yaw rates for a spectrum of
operating conditions and by noting the differences between
computed and measured rudder angles for each operating
condition.

V. PROGRAM SUBROUTINE MODIFICATIONS

A. REPLACEMENT OF CENTER OF PRESSURE CURVE

Newman and Poole reported in Ref. 3 the existence of a pressure wave and the attendant gradual deformation of the surface of the water due to a moving pressure distribution with regard to CAB type hulls. NSRDC found that, in towing tank tests of CAB scale models, the craft tends to pivot in pitch motion about a point approximately 75-80% of the wetted length of the sidewall forward of the transom (Ref. 4). Based on these findings, it has been postulated that the center of volume within the plenum chamber moves aft with increasing speed.

Accordingly, the calculations made in the XR-3 simulation program to account for a shifting center of pressure were removed from subroutines RHS and WAVES. Computations were inserted in the program to account for the addition of an incremental wedge of volume to plenum volume which varies with craft speed. What follows is a description by subroutine of changes which were entered and the basis for the inclusion of the changes.

1. Subroutine INCON

A previously unused space on the input data card number 00701 was used to read in the location of the pressure wave pivot point, measured in feet and tenths of feet forward of the transom. The statement XPWV = TEMP(3)

was inserted in Block 07 in the INCON subroutine. A value
of 17.2 ft. was used for XPWV in this study.

The relationship for wave drag produced by the move-
ment of the pressure bubble over the water surface is,
from Ref. 5:

$$X_{bubble} = - (P_b - P_a)\ C_F\ \frac{4W}{\rho gl}\ .$$

The same formula is mechanized in the simulation program as:

$$FXPWAV = -PBBAR * CF * PWVCON$$

where CF = 0.37 / ((U/FNCON) **1.5655981) and PWVCON =
4.0* WEIGHT /(RHO *G* XLBW). The coefficient 0.37 and the
exponent 1.5655981 are correct for the length to beam ratio
of the XR-3 as determined from Ref. 3. The variable name
WATSLP is given to the slope of the water surface inside the
plenum and is calculated as:

$$WATSLP = PBBAR * CF * PWVCON / WEIGHT.$$

WATSLP represents the angle at the apex of the wedge-shaped
increment of volume to be added to plenum volume. Since
the ratio of PBBAR*CF*PWVCON (i.e. bubble drag) to WEIGHT
will always result in a small number for speeds above hump
speed, the small angle approximation may be used without
loss of accuracy. Therefore, the volume increment due to
the water slope to be added to plenum volume is given by

$$0.5 * WATSLP * XL * AB$$

where XL is the length of the plenum chamber and AB is the
area of the plenum at the water surface. The quantity 0.5
* WATSLP * XL is then the vertical cross sectional area
of the wedge-shaped volume increment.

Two other calculations were added in subroutine
INCON for use in other subroutines during the simulation.
The distance from XPWV from the forward extremity of the
plenum is calculated as

$$XLXPWV = XLBW - XPWV$$

where XLBW represents the plenum length at the water
surface. Also the distance between the craft center of
gravity and XPWV is calculated as

$$XPWVXS = XPWV - XS$$

where XS is the longitudinal center of gravity measured in
feet forward of the transom.

2. Subroutine BOWSL

In the computation for ELSKI, the wetted lenght of
the bow seal, an incremental length is added to the wetted
length of the seal. The increase is due to the water slope
and is calculated simply as

$$XLXPWV * WATSLP$$

and added to the existing expression for ELSKI.

3. Subroutine STNSL

Similar to the wetted length correction in BOWSL,
an incremental correction is computed and applied in
subroutine STNSL. Here the correction is opposite in
sign and is applied to the wetted length of the stern seal,
ELSKI as

$$-XPWV * WATSLP.$$

4. Subroutine RHS

The water slope correction is computed in subroutine
RHS as a continuous variable over the period of any given

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simulation time. Recognizing that WATSLP is calculated as the ratio of bubble wave drag to total craft weight and that bubble wave drag varies with velocity and plenum pressure, WATSLP must be considered as a continuous variable. Accordingly, the following computation was introduced in RHS:

$$\text{WATSLP} = -\text{FXPWAV} / \text{WEIGHT}$$

The plenum volume is corrected for the water slope on each pass through subroutine RHS by the addition of a volume increment as in subroutine INCON:

$$+ .5 * \text{WATSLP} * \text{XL} * \text{AB}.$$

5. Subroutine SIDEWL

The addition of a wedge-shaped volume to plenum volume required an alteration to the computation of the drafts along the sidewalls inside the plenum chamber. Displacement of water is calculated as

$$\text{PBHEAD} = \text{PBAR} / (\text{RHO} * \text{G})$$

where PBAR is the instantaneous plenum pressure. The immersion depth on the inside of each sidewall section is calculated in the relation

$$\text{DDIN} = \text{DD} - \text{WATSLP} * (\text{XPWVXS} - \text{XX}(,\text{K}))$$

where DD represents the uncorrected water level height above the keel along each sidewall section and XX(J,K) is the distance from the transom of the center of each of the eleven stations along the sidewall.

A revision of the method of computing sidewall gaps at any given station was also necessary. A logical IF

statement was included to test each value of DDIN after it was computed. If DDIN is less than zero another logical IF statement must be tested to determine if a gap exists between the bottom of the sidewall (keel) and the water surface. If DSW (J,K), or the actual sidewall immersion depth, is less than PBHEAD, then a gap for that sidewall section is computed as

$$GAP \ (J,K) = - \ DDIN \ * \ (1.-(DSW(J,K))/ \ PBHEAD)$$

where the computed GAP for any given station is in units of feet.

Further background information of use in this study is contained in References 6-11.

B. THRUST VECTORS IN SUBROUTINE PROP

The propulsion system in the XR-3 consists of two forty horsepower outboard motors. The port screw has a right hand rotation and the starboard screw has a left hand rotation. Steering control is obtained by rotation of the motors in the horizontal plane. Thus, there is some rudder effect from the foil-shaped lower motor housings, however the predominant turning moment results from re-alignment of the propulsion thrust vectors when rudder angle is applied. In addition to the main thrust vector, directed in the line of craft motion for zero rudder angle, there exists a side thrust vector for each propeller. Since the propellers are counter-rotating, and due to the direction of rotation of each propeller, the side thrust vectors are

oppositely directed and, for zero rudder angle, are
directed inboard.

The assumption is made that both port and starboard
propulsion motors rotate together through the same rudder
angle. It is also assumed that the magnitude of the main
and side thrust vectors are independent of rudder angle.

The propeller thrust diagram shown in Figure 12 was
used to verify and correct the force and moment equations
for the XR-3 propulsion system. The figure displays the
main thrust and side thrust vectors for both propellers
positioned with right (positive) rudder angle δ, positive
pitch angle θ, and negative (port side down) roll angle ϕ.
The thrust vectors act through the port and starboard pro-
peller positions, XP, YP, and ZP from the craft center of
gravity in the Body Reference coordinate system.

The forces associated with the propeller alignment of
Figure 1 are shown vectorially in Figure 13 in the Local
Level coordinate system after having been corrected for
pitch and roll angles. The assumption is made that pitch
angle and roll angle are limited to small angles such that
$\sin\theta \cong \theta$ and $\cos\theta \cong 1$, $\sin\phi \cong \phi$ and $\cos\phi \cong 1$. The follow-
ing force equations result:

    T1X = THST1 * $\cos\delta$
    T2X = THST2 * $\cos\delta$
    ST1X = - STHST1 * $\sin\delta$
    ST2X = STHST2 * $\sin\delta$
    T1Y = THST1 * $\sin\delta$

ϕ = ROLL ANGLE
θ = PITCH ANGLE
δ = RUDDER ANGLE
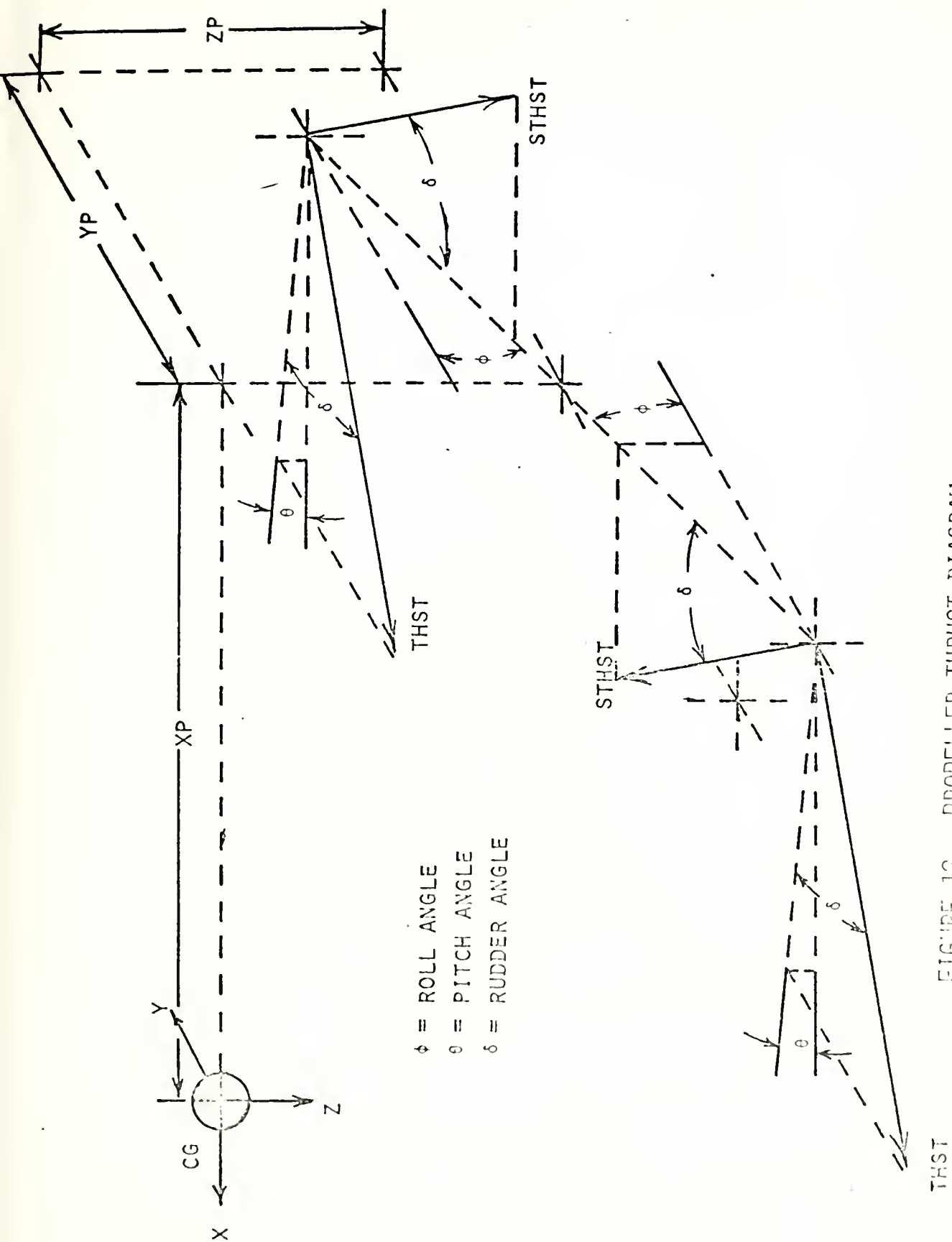
FIGURE 12. PROPELLER THRUST DIAGRAM

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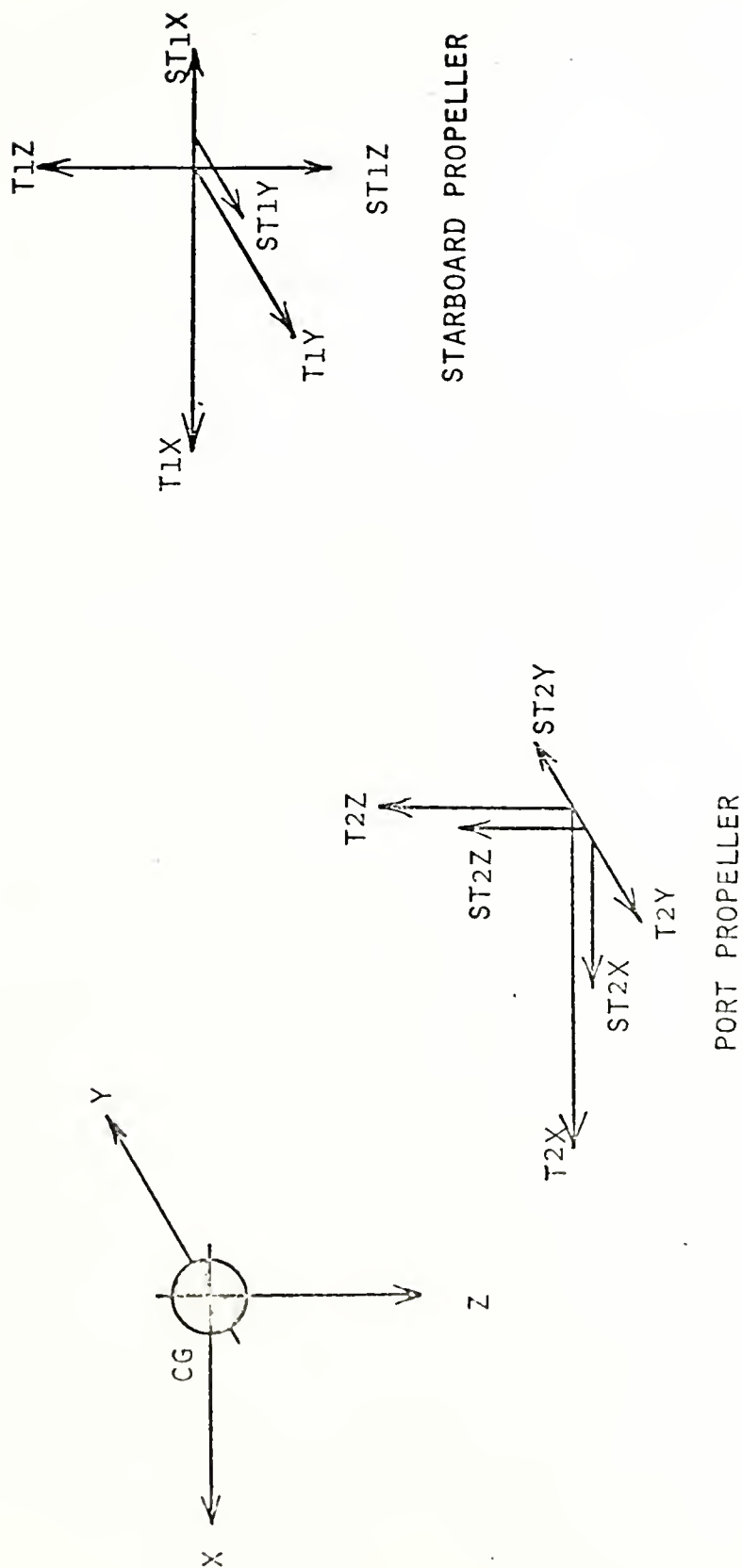
FIGURE 13. VECTOR RESOLUTION OF PROPELLER THRUST FORCES

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$$T2Y = THST2 * \sin \delta$$

$$ST1Y = -STHST1 * \cos \delta$$

$$ST2Y = STHST2 * \cos \delta$$

$$T1Z = THST1 * \cos \delta * \theta$$

$$T2Z = THST2 * \cos \delta * \theta$$

$$ST1Z = STHST1 * \cos \delta * \phi$$

$$ST2Z = STHST2 * \cos \delta * \phi$$

Summing the forces in each of the three corrdinate directions yields the following result:

$$FXS = T1X - ST1X$$

$$FXP = T2X + ST2X$$

$$FYS = - T1Y - ST1Y$$

$$FYP = T2Y + ST2Y$$

$$FZS = - T1Z + ST1Z$$

$$FZP = -T2Z - ST2Z$$

The total force equations are found by summation of the force equations for the port and starboard propulsion systems in each of the three coordinate directions as follows:

$$FX = FXP + FXS$$

$$FY = FYP + FYS$$

$$FZ = FZP + FZS$$

Corrections were made to the force calculations of sub-routine PROP from Reference 1 on the basis of the foregoing discussion.

VI. DISCUSSION AND EVALUATION OF RESULTS

A. OBTAINING AGREEMENT AMONG VARIABLES

Computer simulation runs in the initial stages of this study revealed that plenum pressure was consistently approximately 2.5 psf higher than that recorded on the XR-3 testcraft. Among other variables, thrust on the testcraft was higher than the computer model indicated for any given speed and calculated draft was greater by approximately three inches than the computer model produced. The decision was made to first obtain agreement in plenum pressure between the mathematical model and the testcraft.

The bow seal leakage area input to the mathematical model was listed in Ref. 1 as one of the parameters not known to be exact. The estimate of leakage area was revised from 0.08 sq. ft. to 0.10 sq. ft. This slight alteration had the desired effect of reducing plenum pressure to agree with that measured on the XR-3 testcraft. An unexpected but welcome additional effect was nearly perfect agreement in thrust and draft. Aside from the alterations to the structure of the mathematical model there were no further changes made to the model during the course of the present study.

1. Straight Runs Made with Different C.G. Positions

Validation runs were made interfacing data measured on the XR-3 testcraft with the computer model. The data

presented in Table III is a summary of average differences
calculated between time histories of actual craft motions
and simulated craft motions for the thrust, velocity,
pitch angle, plenum pressure and draft variables. Also
included is percentage differences for ease in qualitative
comparison. It should be noted that percentage differences
in pitch angle measurement appear to be quite large, how-
ever in most cases the difference is within the measurement
accuracy limitation of $\pm$ 0.5 degree aboard the testcraft.

The total craft weight on the measurement runs
listed in Table III was 6270 lbs. In addition to the pilot
there was a passenger in the co-pilot position and 250 lbs.
of water in plastic containers aboard used for changing
the location of the center of gravity of the XR-3.

The data presented in Table IV is a summary of
average time history differences with a fixed center of
gravity on the XR-3. On the measurement runs listed in
Table IV the total craft weight was 6050 lbs. Vertical
acceleration was substituted for draft in this series of
validation runs.

Figures 14, 15, 16, 17, and 18 are typical of the
graphical output from the XR-3 simulation program arranged
to display the time histories of differences between com-
puted and measured variables for this study.

2. Runs Made with Turns

A series of eleven validation runs were made with
various rudder angles at various speeds. A summary of the

TABLE III. SUMMARY OF DIFFERENCES IN STRAIGHT RUNS-A

Average Differences Between Mathematical Model and Measured Variables are Listed *

(Percentage Differences in Parentheses)

Run	Velocity	CG Location	Thrust	Velocity	Pitch	Plenum Press	Draft
1.	18.2 kts	10.15 ft	-9.0 (-1.96)	0.0 (0)	-0.65 (-32.5)	0.0 (0)	-0.6 (-4.9)
2.	18.9	10.27	28.0 (5.9)	0.0 (0)	-0.8 (-38.1)	0.01 (.05)	-2.1 (-15)
3.	16.6	10.03	-17.0 (-3.9)	-0.1 (-0.6)	-0.2 (-10.2)	0.01 (.04)	0.1 (0.86)
4.	14.3	10.03	-38.0 (-8.9)	-0.06 (-0.42)	-0.4 (-18.6)	0.14 (.63)	1.2 (11.3)
5.	16.5	10.15	-12.5 (-3.0)	-0.1 (-0.6)	-0.3 (-14.6)	0.0 (0)	0.6 (5.4)
6.	17.1	10.19	-10.0 (-2.3)	0.0 (0)	-0.3 (-12.0)	0.0 (0)	0.6 (5.4)
7.	13.9	10.067	3.5 (0.9)	0.0 (0)	-0.2 (-9.52)	0.01 (.04)	0.1 (.85)

TABLE III. (Continued)

Run	Velocity	CG Location	Thrust	Velocity	Pitch	Plenum Press	Draft
8.	22.0	10.03	32.0	0.05	0.0	-0.7	-1.4
			(6.4)	(0.2)	(0)	(-3.2)	(-11.2)
9.	12.5	10.15	-8.7	0.07	0.2	0.01	0.5
			(-2.3)	(.6)	(9.1)	(.4)	(4.3)
10.	22.4	10.03	38.0	0.0	0.16	0.0	-1.6
			(7.5)	(0)	(9.3)	(0)	(-11.8)

* NOTE: Negative sign indicates computed variable is smaller than measured variable.

Craft total weight was 6270 lbs. in all runs.

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TABLE IV. SUMMARY OF DIFFERENCES IN STRAIGHT RUNS-B

Average Differences Between Mathematical Model and Measured Variables are Listed *

(Percentage Differences in Parentheses)

Run	Velocity	CG Location	Thrust	Velocity	Pitch	Plenum Press	Vert Accel
1.	20.6 kts	10.15	29.0 (5.6)	0.0 (0)	0.1 (5.3)	0.12 (4.5)	0.01 (2.1)
2.	15.2	10.15	-16.0 (-4.2)	-0.05 (-0.3)	-0.2 (-9.1)	0.02 (0.1)	0.008 (0.9)
3.	14.4	10.15	-11.0 (-3.5)	0.03 (0.2)	0.1 (6.35)	0.05 (0.22)	0.004 (0.45)
4.	18.7	10.15	21.0 (4.8)	0.01 (0.05)	-0.7 (-22.0)	0.01 (0.4)	0.01 (2.1)
5.	22.8	10.15	28.0 (6.4)	0.04 (0.17)	-0.3 (-12.0)	0.06 (0.3)	0.003 (0.4)

* NOTE: Negative sign indicates computed variable is smaller than

measured variable

Craft total weight was 6040 lbs. in all runs.
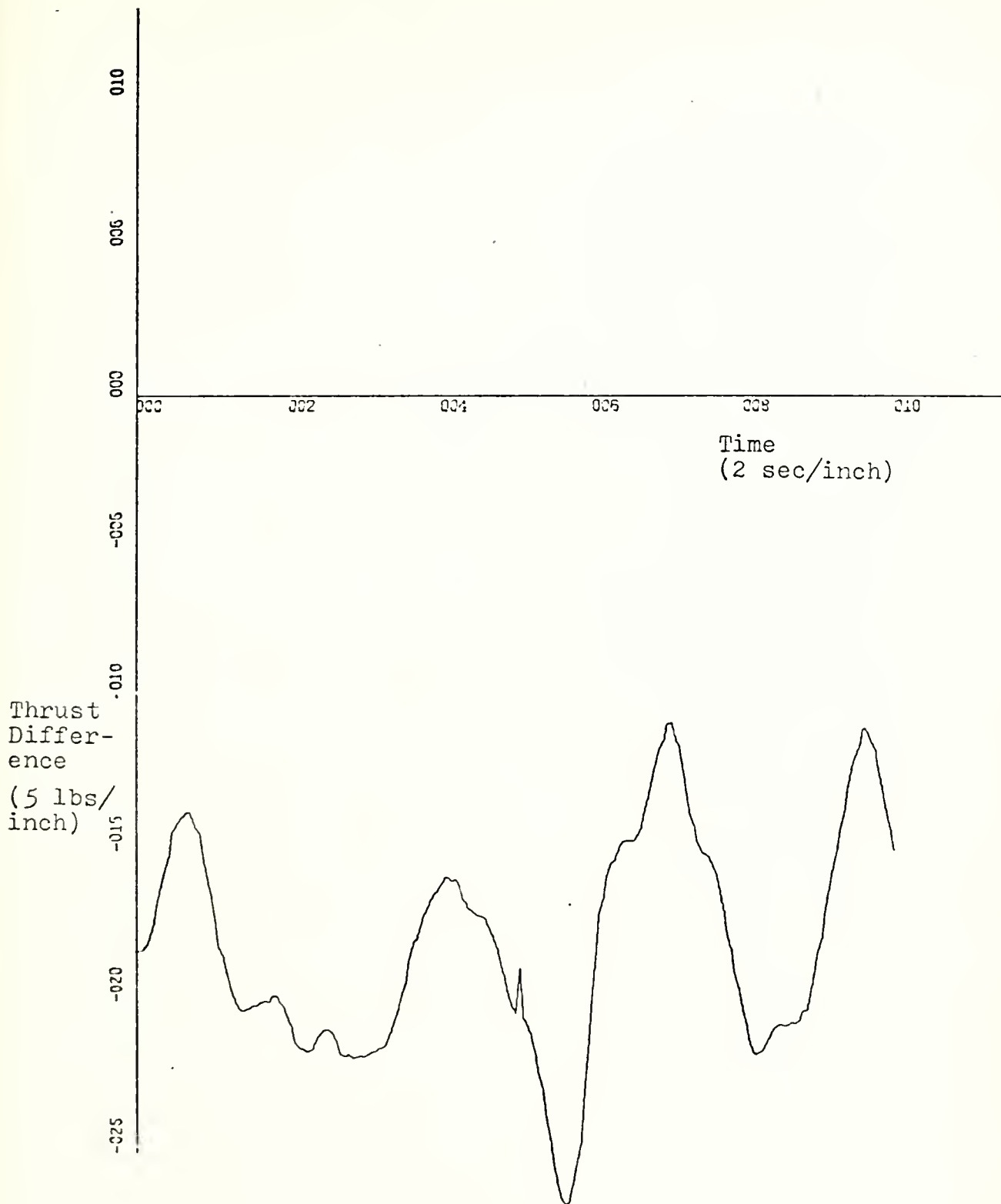
Figure 14. Plot of Thrust Difference Vs. Time

58
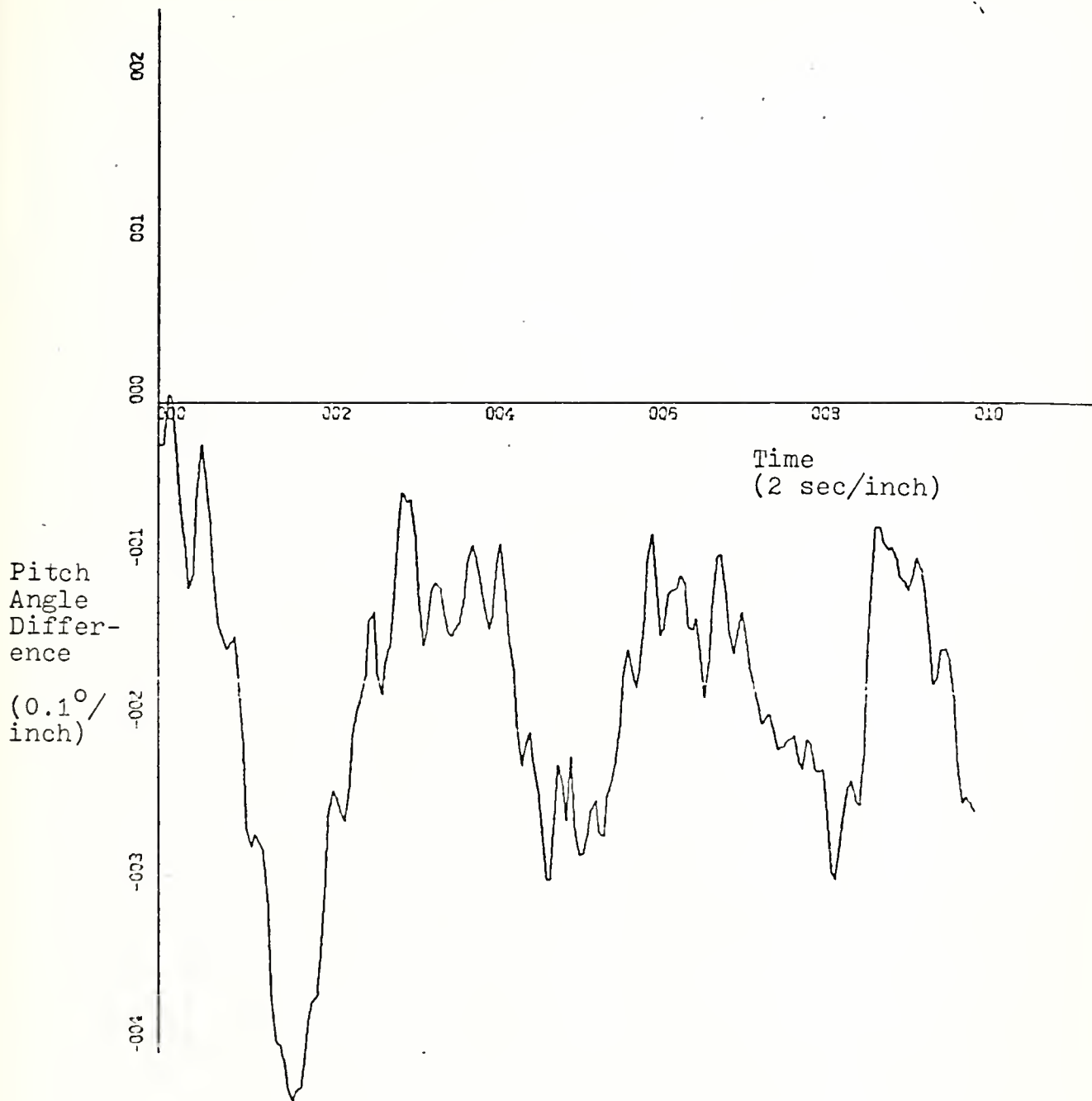
Figure 15.   Plot of Pitch Angle Difference Vs. Time

59
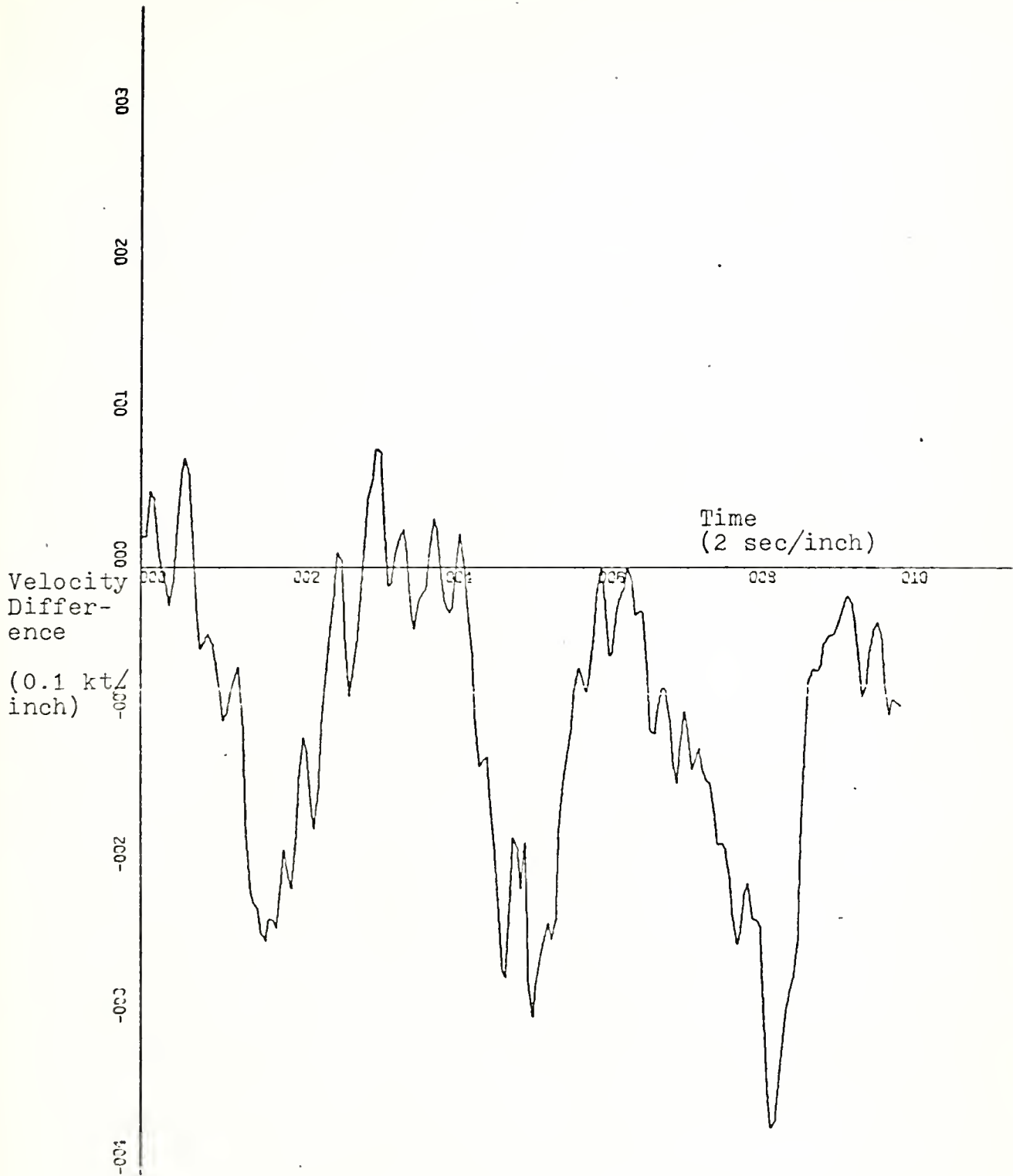
Figure 16. Plot of Velocity Difference Vs. Time

60
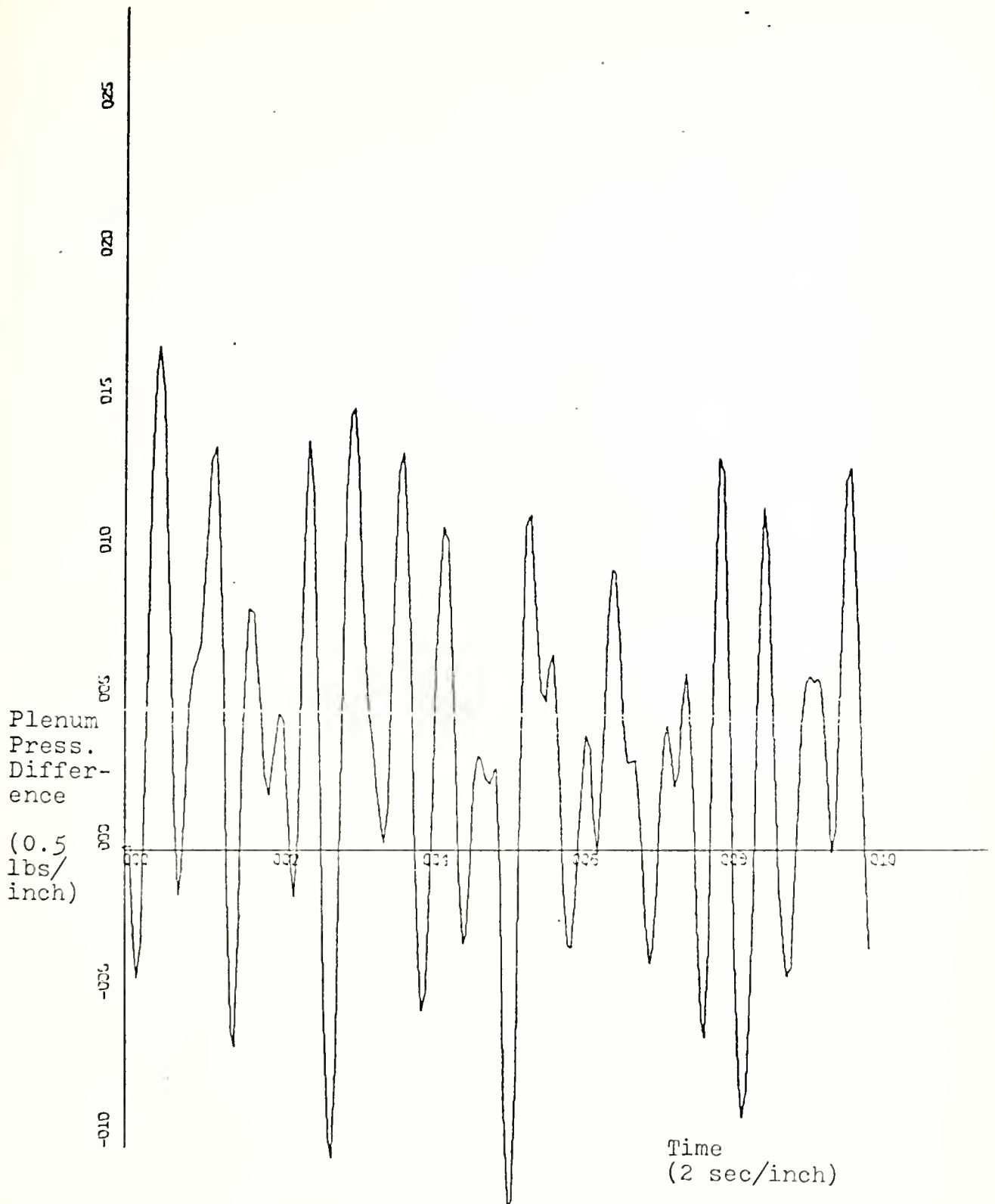
Figure 17. Plot of Plenum Pressure Difference Vs. Time

61
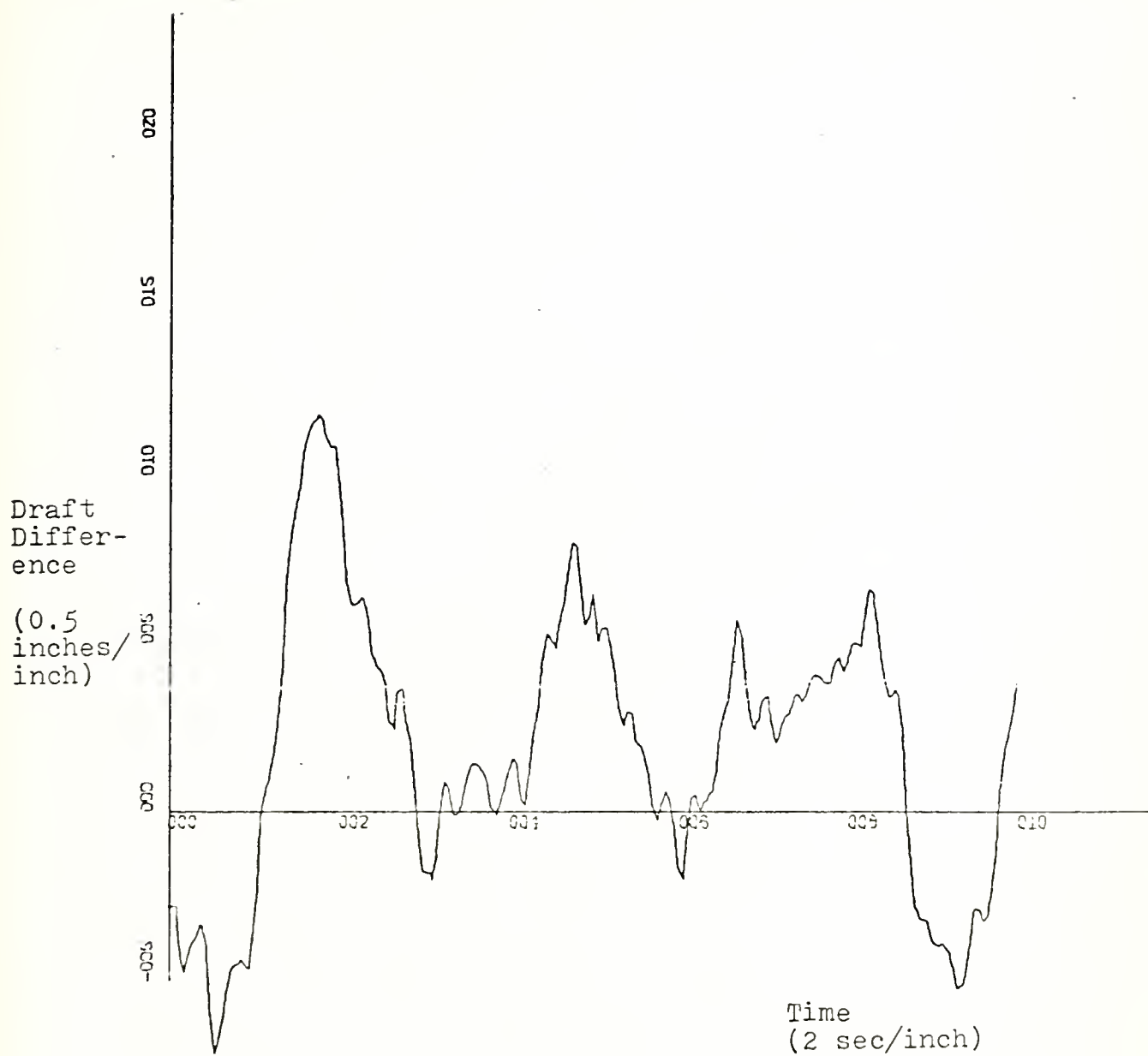
Figure 18.   Plot of Draft Difference Vs. Time

average differences calculated between actual craft motions and simulated craft motions during the turning maneuvers for thrust, velocity, pitch angle, roll angle, yaw angle, yaw rate and rudder position variables is presented in Table V.

The relatively large differences in rudder angles in many runs is attributed to the lack of confidence in an accurate rudder position measurement. In the future when direct steering control of both propulsion motors is restored, it is recommended that confirmation be made of the results presented here with regard to rudder position and other variables in turning maneuvers.

Figures 19, 20, 21 and 22 are typical of the graphical output from the XR-3 simulation program which display the time histories of differences in roll angle, yaw angle, yaw rate, and rudder angle, respectively.

B.   LIMITED TO CALM WATER CASES

It is recognized that much of the measurement data obtained at the XR-3 test site at Lake San Antonio, California contains small perturbations due to surface disturbances on the lake. No attempt has been made to measure the surface disturbances or their effect on the testcraft. Validation of the mathematical model in the presence of waves of any amplitude and wavelength is suggested as an area for further study.

TABLE V. SUMMARY OF DIFFERENCES IN TURNS

Average Differences Between Mathematical Model and Measured Parameters are Listed *

(Percentage Differences in Parentheses)

Run	Rudder Ang	Velocity	Thrust	Velocity	Pitch	Roll	Yaw	Yaw Rate	Rudder Ang
1.	L 4.5°	19.7 kts	8.5 (2.2)	0.0 (0)	-.36 (-13.4)	0.03 (6.5)	3.63 (22.7)	0.01 (7.0)	-3.0 (-40)
2.	L 3.0	24.7	12.0 (2.5)	0.0 (0)	-.3 (-13.4)	0.04 (8.0)	0.5 (4.7)	0.2 (21.7)	-3.0 (-50)
3.	L 3.0	13.7	-17 (-4.9)	-0.08 (-.3)	-.7 (-38.6)	0.03 (18.7)	-.15 (1.85)	0.0 (0)	-8.0 (-72)
4.	L 3.3	25.1	28.0 (5.8)	0.0 (0)	0.05 (2.2)	0.22 (38.6)	1.8 (15.2)	0.3 (29.1)	0.65 (16)
5.	L 5.4	16.3	-14.0 (-3.9)	0.0 (0)	0.09 (4.7)	0.1 (40)	-.73 (-6.2)	0.09 (6.4)	-1.3 (-23)
6.	L 5.8	21.5	-21.0 (-4.9)	0.06 (0.3)	0.29 (11.6)	0.23 (44)	1.1 (6.3)	0.05 (2.6)	1.4 (31)
7.	R 4.1	19.6	27.0 (6.8)	-0.06 (-0.3)	-0.38 (-20)	-0.1 (-25.6)	0.2 (1.4)	0.04 (3.1)	0.7 (14.6)

TABLE V. (Continued)

Run	Rudder Ang	Velocity	Thrust	Velocity	Pitch	Roll	Yaw	Yaw Rate	Rudder Ang
8.	R 3.8	19.6	28.0 (7.1)	-0.03 (-0.2)	-0.4 (-20.7)	-0.13 (-36)	0.96 (7.4)	0.05 (4.2)	0.44 (10.4)
9.	R 6.1	20.2	-18.0 (-4.5)	0.05 (0.2)	-0.21 (-10.5)	0.15 (31.2)	1.9 (9.2)	0.0 (1.8)	-2.5 (-29)
10.	R 3.9	18.1	16.0 (4.2)	0.0 (0)	0.06 (3.1)	0.1 (20)	0.62 (5.3)	0.03 (2.2)	-0.9 (-19)
11.	R 5.6	15.7	12.0 (5.1)	0.0 (0)	-0.04 (-2.6)	0.03 (19.4)	0.51 (6.1)	0.17 (9.8)	1.2 (17.6)

* NOTE: Negative sign indicates computed variable is smaller than measured variable.

Craft total weight was 6040 lbs. in all runs.

65
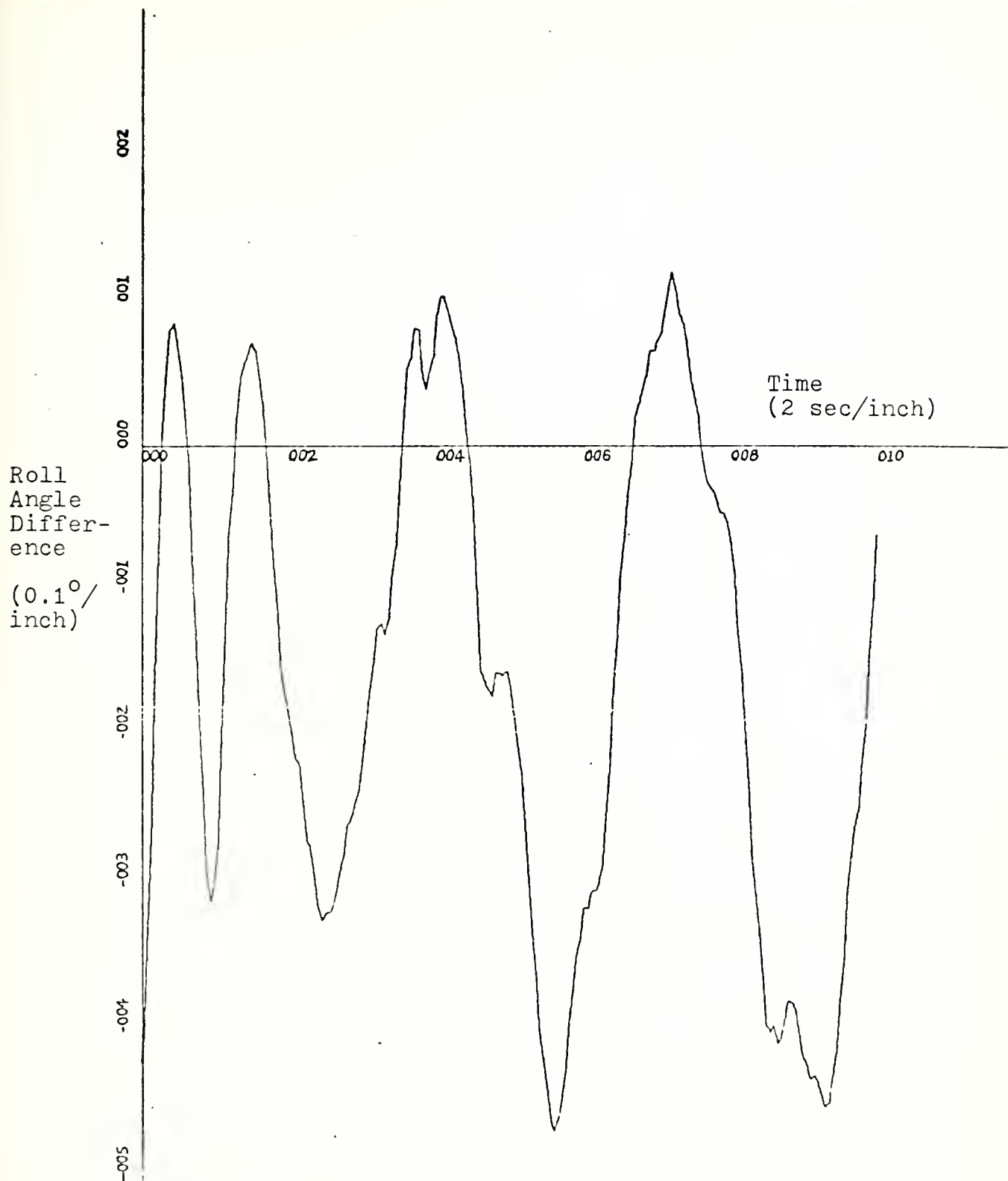
Figure 19.   Plot of Roll Angle Difference Vs. Time

Figure 20.   Plot of Yaw Angle Difference Vs. Time
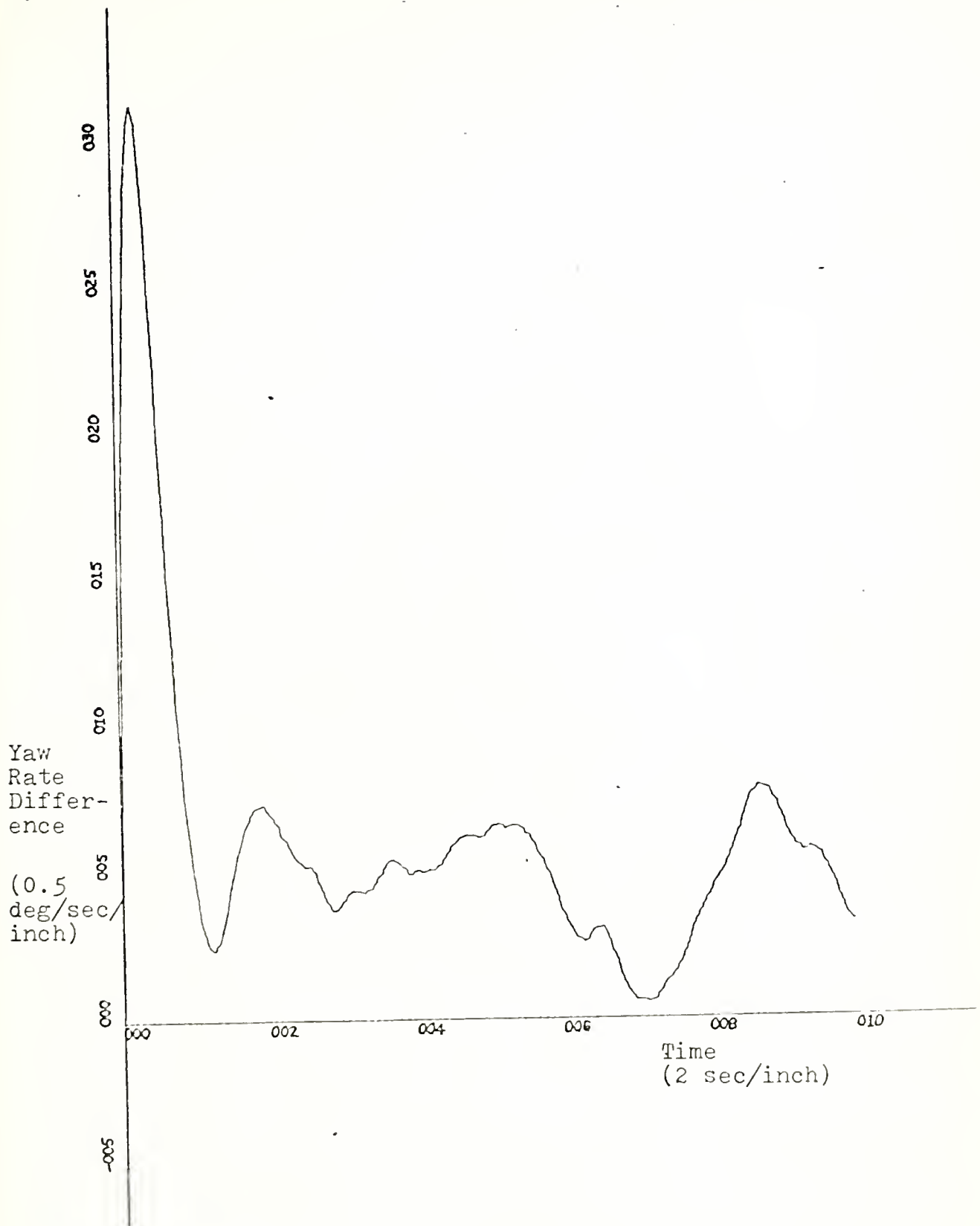
Figure 21.   Plot of Yaw Rate Difference Vs. Time

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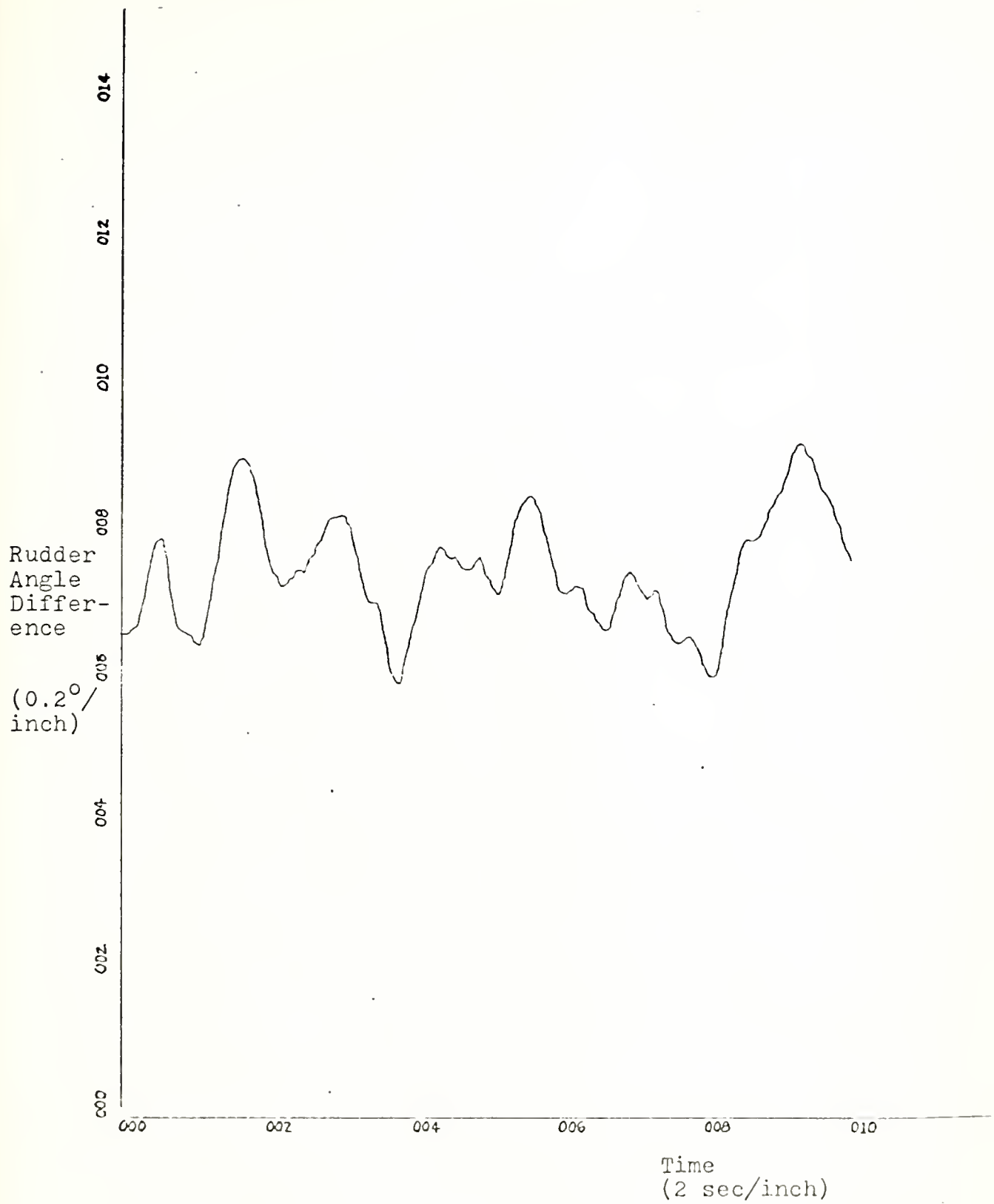
Figure 22. Plot of Rudder Angle Difference Vs. Time

A listing of the FORTRAN program for simulation of the XR-3 is included as Appendix D. A sample input data deck is also included.

VII.   CONCLUSIONS AND RECOMMENDATIONS

This study has shown that the nonlinear mathematical
model with six degrees of freedom adequately describes the
motions of the XR-3 in calm water conditions. The variables
used in the validation included thrust, longitudinal velo-
city, pitch angle, plenum pressure, draft and vertical
acceleration in straight runs. For validation of turning
dynamics the variables included thrust, longitudinal velo-
city, pitch angle, roll angle, yaw angle, yaw rate and
rudder angle. Differences that were found to exist between
the computer model and the testcraft were less than 5% for
the majority of the variables compared and those differ-
ences that exceeded 5% are considered acceptable, given
the range of the measured variables and the accuracy of
the sensors aboard the testcraft.

During the course of this study, it became apparent
that the computer model exhibits a more oscillatory, or
underdamped, response in pitch and roll motions than does
the XR-3 testcraft. A concurrent study by LCDR. R.A. Finley,
USN upon this aspect of the simulation with attention to
the modelling of the bow seal and the lift fan system
is reported in Reference 12.

The method of data processing set forth in this study
to produce data in adequate form for interface with the
mathematical model is recommended for use in future

validation efforts. A considerable amount of time and
effort was spent in signal analysis and data processing
to prepare the measured data in a form useful for compari-
son with the mathematical model variables. In order to
eliminate the requirement for smoothing the re-scaled
data, it is recommended that a study be made using a lower
sampling rate for the A-to-D conversion to see if the high
frequency noise can be eliminated from the digitally re-
produced data. It is also recommended that a vibration
study be conducted aboard the XR-3 in an attempt to deter-
mine if the source or sources of the high frequency noise
is the result of internal ship vibration acting on the
measurement transducers, gyros, and accelerometers. The
current data acquisition system installed in the testcraft
should be adequate for such a study.

A very fertile area for future study would be valida-
tion of the computer model in the presence of waves.
Instrumentation exists to measure wave conditions at the
XR-3 test site during measurement runs and the simulated
waves could be input to the mathematical model. Direct
comparison of craft behavior and simulation model calcula-
tions could then be obtained to produce an evaluation of
the accuracy of the simulation in sea states.

LISTING OF FORTRAN PROGRAM FOR ANALOG TO

DIGITAL CONVERSION OF MEASURMENT DATA

```
      DIMENSION IBUF(4096,2),LOCB(-1'1),BADREC(100)
      INTEGER RECNUM,BADREC
      NAMELIST NREC, NSAMP, NCHAN, ITAPE,NDEL,NT
1     INPUT(101)
      NWORDS=NSAMP*NCHAN
      LOCB(-1)=LOCF(IBUF(1,1))
      IF NREC.GT.1,LOCB(1)=LOCF(IBUF(1,2))
      IF NREC.EQ.1,LOCB(1)=LOCB(-1)+NWORDS
      IND=2
      GO TO 15
2     NB=1
      RECNUM=0
      NEWBUF=LOCB(1)
      IF(IABS(IND).NE.2)GO TO 94
      CALL WRITECLOCK(O)
      CALL ADSTART(NCHAN,LOCB(-1),NEWBUF,NSAMP,RECNUM,11S)
      CALL MTRDY(ITAPE,LOCB(-1),LOCB(1),NWORDS,IND)
4     IF IND.EQ.1, GO TO 4
      GO TO(4,3,91,93)IND
3     IF NT.EQ.0,GO TO 7
      CALL MTRDY1(ITAPE+1,LOCB(-1),LOCB(1),NWORDS,IND)
6     IF IND.EQ.1,GO TO 6
      GO TO(6,7,91,93)IABS(IND)
7     IF(TEST(1).GT.0)GO TO 7
      IND=2
      NBAD=0
      CALL STARTCLOCK
      CALL ENABLE
5     CONTINUE
10    GO TO 5
11    NB=-NB
      NEWBUF=LOCB(NB)
      IF(TEST(1).GT.0.OR.RECNUM.GE.NREC)CALL DISABLE
      GO TO(90,12,91,92)IABS(IND)
12    CONTINUE
      IF(IND.GT.0)CALL MTOUT(NB)
      IF(IND.LT.0)CALL MTOUT1(NB)
      IF(TEST(1).LT.0.AND.RECNUM.LT.NREC)GO TO 5
      CALL STOPCLOCK
      CALL ADSTOP
      CALL PROCESS(IBUF,NSAMP,NCHAN+1,2S)
      OUTPUT( 6 )RECNUM
      IF NBAD.NE.0,WRITE( 6 ,106) (BADREC(I),I=1,NBAD)
106   FORMAT($ BAD RECORDS ARE$,(/,I6))
15    OUTPUT(102)'OPTION=(I1)'
      READ(101,100)NOPT
100   FORMAT(I1)
      GO TO(1,2,30,40,50,60,70)NOPT
30    OUTPUT(102)'EOF ON WHICH TAPE'
      READ(101,100)N
      IF N.EQ.0,GO TO 15
      ENDFILE(N)
      GO TO 15
40    OUTPUT(102)'REWIND WHICH TAPE'
      READ(101,100)N
      IF N.EQ.0,GO TO 15
      REWIND(N)
      GO TO 15
50    OUTPUT(102)'SKIPFILES=(I4)'
      READ(101,101)NF
101   FORMAT(I4)
      OUTPUT(102)'ON WHICH TAPE'
```

```
      READ(101,100)N
      IF N.EQ.0,GO TO 15
      DO 55 I=1,NF
51    CALL BUFFERIN(N,1,IBUF(1,1),1,IN )
52    IF(IN .LT.2)GO TO 52
      IF(IN .NE.3)GO TO 51
55    CONTINUE
      OUTPUT(102)NF
      GO TO 15
60    OUTPUT(102)'NUMWORDS TO LIST=(I4)'
      READ(101,101)NW
      OUTPUT(102)'FROM WHICH TAPE'
      READ(101,100)N
      IF N.EQ.0,GO TO 15
601   IN =1
      CALL BUFFERIN(N      ,1,IBUF(1,1),NWORDS,IN )
66    IF(IN .EQ.1)GO TO 66
62    GO TO(62,63,64,65)IN
63    WRITE(6,102)
102   FORMAT(1H1)
      DO 631 I=1,NW,NCHAN
      WRITE(6,104)(IBUF(J,1),J=I,I+NCHAN-1)
104   FORMAT(12O10)
631   CONTINUE
      IF (SENSE SWITCH 1)601,15
64    OUTPUT(102)'EOF READ'
      GO TO 15
65    OUTPUT(102)'READ ERR'
      GO TO 63
70    OUTPUT(102)'D/A FROM WHICH TAPE'
      READ(101,100)N
      IF N.EQ.0,GO TO 15
      OUTPUT(102)'TYPE * C/R TO CONTINUE'
      INPUT(101)
77    IN =1
      CALL BUFFERIN(N      ,1,IBUF,NWORDS,IN )
76    IF(IN .EQ.1)GO TO 76
71    GO TO(71,72,64,74)IN
72    DO 73 I=1,NWORDS
73    IBUF(I,1)=IBUF(I,1)/2**10
      DO 75 I=1,NWORDS,NCHAN
      DO 750 J=1,NCHAN
750   CALL DAC(J,IBUF(I+J-1,1))
      M=NDEL
      CALL DELAY
75    CONTINUE
      IF(SENSE SWITCH 1)77,15
74    OUTPUT(102)'READ ERROR'
      GO TO 72
90    CALL DISABLE
      CALL ADSTOP
      OUTPUT(102)'RATE ERR',RECNUM
      GO TO 15
92    IF NBAD.LT.100,NBAD=NBAD+1
      BADREC(NBAD)=RECNUM-1
      GO TO 12
91    CALL DISABLE
      CALL ADSTOP
      OUTPUT(102) - MT NOT READY -
      GO TO 15
93    CALL DISABLE
      CALL ADSTOP
      OUTPUT(102) - MT ERROR ON SPACING FROM LOAD POINT-
      GO TO 15
94    OUTPUT(102)'DELAY TIME BETWEEN RECORDS TOO SHORT'
      GO TO 15
      END
```

```
      SUBROUTINE PROCESS(I,N,NC,IR)
      J=N*NC*9
      CALL DELAY
1     IF TEST(1).LT.0,GO TO 1
      IF TEST(2).GT.0,RETURN IR
      RETURN
      END
```

APPENDIX B

LISTING OF FORTRAN PROGRAM TO READ FROM

SEVEN TRACK TAPE, CONVERT FROM OCTAL TO

HEXADECIMAL, AND STORE RESULT ON DISK

```
//CONVERT EXEC FORTCLG,REGION.GO=100K
//FORT.SYSIN DD *
      DIMENSION IDAT(3072), DAT(3072)
      FACTOR=100./(2**23)
      REWIND 2
      NRECL = 3072
      J=0
10    READ(2,15,END=50,ERR=60) IDAT
15    FORMAT (16(192A4))
      J=J+1
      WRITE (6,70) J
70    FORMAT ('0',10X,'RECORD NO.=',I4)
      CALL FORM(IDAT,NRECL)
      DO 22 I=1,NRECL
22    DAT(I)=IDAT(I)*FACTOR
      WRITE (6,40) (DAT(I),I=1,180)
40    FORMAT (1X,6F12.5)
      WRITE (4) DAT
      GO TO 10
60    WRITE(6,61) J
61    FORMAT ('0',5X,'READ ERROR RECORD NO.=',I3)
      GO TO 10
50    WRITE (6,51) J
51    FORMAT ('0',5X,'END OF TAPE, RECORD NO.=',I3)
      ENDFILE 4
      RETURN
      END

//GO.FT02F001 DD UNIT=2400-1,VOL=SER=BOTEY,LABEL=(9,NL,,IN),
//  DISP=OLD,DCB=(DEN=1,RECFM=F,BLKSIZE=12288)
//GO.FT04F001 DD UNIT=2314,DSNAME=S0896.TAPESS,DISP=(NEW,KEEP),
//  VOL=SER=DUFFY,RETPD=120,SPACE=(TRK,(2,2),RLSE),
//  LABEL=RETPD=120,SPACE=(TRK,(2,2),RLSE),
//  DCB=(RECFM=VS,BLKSIZE=3504,LRECL=3000)
```

76

LISTING OF FORTRAN PROGRAM TO READ FROM DISK,

RESCALE DATA TO MEASURED UNITS, PERFORM SMOOTHING,

AND STORE THE RESULT ON DISK

```
//  EXEC FORTCLGP,REGION.GO=200K
//FORT.SYSIN DD *

      INTEGER*4  ITB(12)/12*0/
      REAL*4 RTB(28)/28*0.0/
      EQUIVALENCE (TITLE,RTB(5))
      REAL*8 TITLE(12)
      DIMENSION TP(2000),TS(2000),HT(2000),PANG(2000),PB(2000),
     1VK(2000),TTHST(200),PITCH(200),PBUB(200),SPD(200),DRFT(200),
     2TIME(200)
      READ (5,110) NPTS
110   FORMAT (I4)
      M=500
      N=1
      DO 5  K=1,4
      READ (4) (JP(I),TS(I),HT(I),PANG(I),VK(I),PB(I),I=N,M)
      N=500+N
      M=500+M
5     CONTINUE
      CALL SMOOTH (TP)
      CALL SMOOTH (TS)
      CALL SMOOTH (HT)
      CALL SMOOTH (PANG)
      CALL SMOOTH (VK)
      CALL SMOOTH (PB)
      DO 10 J=1,200
      K=J
      TTHST(J)=(TP(K)+TS(K))*10.
      PITCH(J)=(PANG(K)-25.)*0.6
      PBUB(J)=PB(K)*1.2
      SPD(J)=VK(K)*0.8
      HT(J)=(100.-HT(K))*0.48
      DRFT(J)=48.0-HT(J)-3.19335*PITCH(J)
      TIME(J)=(J-1)*0.05
10    CONTINUE
      WRITE(6,165) (I,TTHST(I),DRFT(I),PITCH(I),SPD(I),PBUB(I),I=1,200)
```

```
165   FORMAT(//3X,I4,5F12.4)
      WRITE(8)(TTHST(I),DRFT(I),PITCH(I),SPD(I),PBUB(I),I=1,200)
      READ (5,100) TITLE
100   FORMAT (6A8)
      CALL DRAWP(NPTS,TIME,TTHST,ITB,RTB)
      READ (5,100) TITLE
      CALL DRAWP(NPTS,TIME,PITCH,ITB,RTB)
      READ (5,100) TITLE
      CALL DRAWP(NPTS,TIME,PBUB ,ITB,RTB)
      READ (5,100) TITLE
      CALL DRAWP(NPTS,TIME,SPD  ,ITB,RTB)
      READ (5,100) TITLE
      CALL DRAWP(NPTS,TIME,DRFT ,ITB,RTB)
      STOP
      END

      SUBROUTINE SMOOTH (VBLE)
      DIMENSION VBLE(2000)
      SUM=0.0
      N=1
      M=10
      DO 210  I=1,200
      DO 205  K=N,M
      SUM=SUM+VBLE(K)
205   CONTINUE
      VBLE(I)=0.1*SUM
      N=N+5
      M=M+5
      SUM=0.0
210   CONTINUE
      RETURN
      END

//GO.FT04F001 DD  DISP=SHR,DSN=S0896,TAPESS,UNIT=2314,VOL=SER=DUFFY,
//       LABEL=(,,,IN),DCB=(RECFM=VS,BLKSIZE=3504,LRECL=3000)
//FT03F001 DD DSN=S0896,DATAIO,UNIT=2314,VOL=SER=MARY,DISP=(NEW,KEEP),
//       LABEL=RETPD=180,DCB=(RECFM=VS,LRECL=4004,BLKSIZE=7290),
//       SPACE=(TRK,(2,1))
```

```
INTEGER ON                                                            MAIN00010

COMMON /AIR/ PINF,RHOINF,GAM                                          MAIN00020
COMMON /BARO/    IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYMAIN00030
COMMON /CONST/  PI,RAD,UO                                             MAIN00040
COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,         MAIN00050
ATIP(25),TIS(25)                                                      MAIN00060
COMMON /EQNCO/   NEQS,TCL(20),JQQ                                     MAIN00070
COMMON /FPROP/ FXP,FYP,FZP,FKP,FMP,FNP                                MAIN00080
COMMON /FPROP/ FN,FNCKIT                                              MAIN00090
COMMON /FROUDE/ STIME,FTIME,DELT,DELPNT,TPRINT                        MAIN00100
COMMON /PRINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,       MAIN00110
-IRUD,IPRUP,IAEROD,IRHS                                               MAIN00120
COMMON /KOLL/ PHIMAX,TROLL                                            MAIN00130
COMMON /RUDOR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,     MAIN00140
ARCLB,RTC,RUDANG,TIR(25)                                              MAIN00150
COMMON / VALOLD / YOLD(20)                                            MAIN00160
COMMON / VARBLE/ VAL(40)                                              MAIN00170
COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVCLW,NWAVE,BETA,            MAIN00180
FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                                   MAIN00190
1        ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR                   MAIN00200
2                                                                     MAIN00210

EQUIVALENCE                                                           MAIN00220
1(VAL(5),P),(VAL(6),Q),(VAL(2),U),(VAL(3),V),(VAL(4),W),              MAIN00230
2(VAL(10),Z),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),                  MAIN00240
3(VAL(24),PB),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),  MAIN00250
DIMENSION DUMMY(20)                                                   MAIN00260
                                                                      MAIN00270
TC=1.0                                                                MAIN00280
ON=1                                                                  MAIN00290
PI=4.*ATAN(1.)                                                        MAIN00300
RAD=180./PI                                                           MAIN00310
WRITE(6,100)                                                          MAIN00320
100 FORMAT(1H1//35X,22H LISTING OF INPUT DECK  //)                    MAIN00330
99  READ(44,101,END=104) DUMMY                                        MAIN00340
101 FORMAT(20A4)                                                      MAIN00350
105 WRITE(6,102)DUMMY                                                 MAIN00360
102 FORMAT(5X,20A4)                                                   MAIN00370
    GO TO 99                                                          MAIN00380
104 REWIND 5                                                          MAIN00390
                                                                      MAIN00400
                                                                      MAIN00410
                                                                      MAIN00420
```

```
11    CALL INCON(TIME)                                           MAIN0430
      IF(IMM.EQ.3) GO TO 605                                     MAIN0440
                                                                 MAIN0450
10    DO 10 J=1,20                                               MAIN0460
      YOLD(J)=VAL(J+1)                                           MAIN0470
      GO TO 2                                                    MAIN0480
                                                                 MAIN0490
1     CONTINUE                                                   MAIN0500
      TOLD=TIME                                                  MAIN0510
      PBBAR=PBBAR*(1.-DELT/TC)+DELT*(PB-PINF)/TC                 MAIN0520
      IF(NWAVE.LE.0) GO TO 13                                    MAIN0530
      ZBAR=(1.-DELT/TC)*ZBAR+DELT*Z/TC                           MAIN0540
      PHIBAR=(1.-DELT/TC)*PHIBAR+DELT*PHI/TC                     MAIN0550
      THEBAR=(1.-DELT/TC)*THEBAR+DELT*THETA/TC                   MAIN0560
      CALL WAVES(TIME)                                           MAIN0570
                                                                 MAIN0580
13    CALL SIDEWL                                                MAIN0590
      CALL PROP                                                  MAIN0600
      CALL RUDDER                                                MAIN0610
      CALL AERO                                                  MAIN0620
      CALL INTCRL(TIME)                                          MAIN0630
      IF(TIME.GT.FTIME) GO TO 12                                 MAIN0640
      IF(FN.GT.FNCRIT) GO TO 14                                  MAIN0650
      PRINT 505                                                  MAIN0660
      GO TO 12                                                   MAIN0670
                                                                 MAIN0680
14    DELOLD=TIME-TOLD                                           MAIN0690
      PSI=PSI+DELOLD*R                                           MAIN0700
      X=X+DELOLD*(U*COS(PSI)-V*SIN(PSI))                         MAIN0710
      Y=Y+DELOLD*(U*SIN(PSI)+V*COS(PSI))                         MAIN0720
15    IF(ABS(TIME-TPRINT).LT.1.E-6) GO TO 2                      MAIN0730
      GO TO 1                                                    MAIN0740
                                                                 MAIN0750
2     CONTINUE                                                   MAIN0760
      IF(ITRAJ.EQ.0) GOTO 16                                     MAIN0770
      DPHI=PHI*RAD                                               MAIN0780
      DPSI=PSI*RAD                                               MAIN0790
      DTHETA=THETA*RAD                                           MAIN0800
      DP=P*RAD                                                   MAIN0810
      DQ=Q*RAD                                                   MAIN0820
      DR=R*RAD                                                   MAIN0830
      VEL=0.5925*U                                               MAIN0840
      WRITE(6,500) TIME,VEL,V,W,DP,DQ,DR,Z,DPHI,DTHETA,X,Y,DPSI  MAIN0850
      BETS=(-V/U)*RAD                                            MAIN0860
      DELRS=RUDANG*RAD                                           MAIN0870
      WRITE(6,501) BETS,DELRS,FXP                                MAIN0880
16    CONTINUE                                                   MAIN0890
      IMMTAG = (IMM+1)/2                                         MAIN0900
```

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```
      IF ( IMMTAG .EQ. 1 .AND. TIME.GE.BTIME-1.E-8 )   IMT = 1            MAIN0910
      TPRINT=TPRINT+DELPNT                                                MAIN0920
      ON=1                                                                MAIN0930
      GO TO 1                                                             MAIN0940
                                                                          MAIN0950
   12 CALL COLFIL                                                         MAIN0960
      IF ( IMM.LT.1)    GO TO 11                                          MAIN0970
      IF ( IMM.NE.1)    GO TO 605                                         MAIN0980
      END FILE IBMFIL                                                     MAIN0990
      GO TO 11                                                            MAIN1000
  605 CALL SAM                                                            MAIN1010
      GO TO 11                                                            MAIN1020
  500 FORMAT(//10X,13HTIME (SEC) =   F6.2//10X,33HTRANSLATIONAL VELS (KTSMAIN1030
     1)/(FT/SEC) /10X,2HU= F6.2,5X,2HV= F6.2,5X,2HW= F6.3//10X,31HROTATIMAIN1040
     2ONAL VELOCITIES (DEG/SEC) /10X,2HP= F6.2,5X,2HQ= F6.2,5X,2HR= F6.2MAIN1050
     3//10X,30HDISPLACEMENTS (FT AND DEGREES) /10X,2HZ= F7.3,5X,4HPHI=    MAIN1060
     4F6.2,3X,6HTHETA= F6.2//10X,27HTRAJECTURY (FT AND DEGREES) /10X,     MAIN1070
     52HX= F8.2,4X,2HY= F8.2,4X,4HPSI= F8.2)                              MAIN1080
  501 FORMAT(1H0,9X,23HSIDESLIP ANGLE (DEG) =    F8.2,10X,21HRUDDER ANGLEMAIN1090
     1 (DEG) = F8.3,10X,15HTHRUST (LBS) =  (DEG) =  F12.1)                MAIN1100
  505 FORMAT(///25X,28HCRAFT SPEED BELOW HUMP SPEED )                     MAIN1110
      END                                                                 MAIN1120
      BLOCK DATA                                                          MAIN1130
      COMMON /AIR/ Z1(3)                                                  MAIN1140
      COMMON /BMCO/ Z2(25)                                                MAIN1150
      COMMON /COLUMN/ Z3(2)                                               MAIN1160
      COMMON /CONST/ Z4(3)                                                MAIN1170
      COMMON /CNTRL/ Z5(10)                                               MAIN1180
      COMMON /ENGINE/ Z6(107)                                             MAIN1190
      COMMON /EQNCO/ Z7(22)                                               MAIN1200
      COMMON /FAERO/ Z8(6)                                                MAIN1210
      COMMON /FAIR/ Z9(2)                                                 MAIN1220
      COMMON /FANMAP/ Z10(262)                                            MAIN1230
      COMMON /FORES/ Z11(7)                                               MAIN1240
      COMMON /FORSS/ Z12(8)                                               MAIN1250
      COMMON /FPROP/ Z13(6)                                               MAIN1260
      COMMON /FRUDDE/ Z14(2)                                              MAIN1270
      COMMON /FRUD/ Z15(6)                                                MAIN1280
      COMMON /GBOW/ Z16(1)                                                MAIN1290
      COMMON /GEOM/ Z17(138)                                              MAIN1300
      COMMON /GEOMBS/ Z18(62)                                             MAIN1310
      COMMON /GEOMSS/ Z19(62)                                             MAIN1320
      COMMON /GEU4SW/ Z20(11)                                             MAIN1330
      COMMON /KSWTCH/ Z21(1)                                              MAIN1340
      COMMON /LEAKER/ Z22(4)                                              MAIN1350
      COMMON /MASSES/ Z23(817)                                            MAIN1360
      COMMON /MATRIX/ Z24(36)                                             MAIN1370
      COMMON /MSIDW/ Z25(55)                                              MAIN1380
```

```
COMMON /MWAVE/ Z26(12)                                                  MAIN1390
COMMON /OPTION/ Z27(4)                                                  MAIN1400
COMMON /PLENUM/ Z28(4)                                                  MAIN1410
COMMON /PLVCRQ/ Z28A(4)                                                 MAIN1420
COMMON /PRIME// Z29(5)                                                  MAIN1430
COMMON /PRTINT/ Z30(12)                                                 MAIN1440
COMMON /PWAVE// Z31(2)                                                  MAIN1450
COMMON /RISER/ Z32(1)                                                   MAIN1460
COMMON /ROLL/ Z33(2)                                                    MAIN1470
COMMON /RUDDR/ Z34(62)                                                  MAIN1480
COMMON /SIDE// Z35(22)                                                  MAIN1490
COMMON /SOFTBS/ Z36(19)                                                 MAIN1500
COMMON /SOFTSS/ Z37(19)                                                 MAIN1510
COMMON /STABLE/ Z38(5)                                                  MAIN1520
COMMON /STSLR/ Z39(2)                                                   MAIN1530
COMMON /VALOLD/ Z40(20)                                                 MAIN1540
COMMON /VARBLE/ Z41(40)                                                 MAIN1550
COMMON /WAVE// Z42(80)                                                  MAIN1560
COMMON /WAVEF/ Z43(40)                                                  MAIN1570
COMMON /SLOPE/ Z44(4)                                                   MAIN1580
DATA Z1/3*0.0/                                                          MAIN1590
DATA Z2/5*0.0/                                                          MAIN1600
DATA Z4/3*0.0/                                                          MAIN1610
DATA Z5/107*0.0/                                                        MAIN1620
DATA Z7/21*0.0/                                                         MAIN1630
DATA Z8/6*0.0/                                                          MAIN1640
DATA Z9/2*0.0/                                                          MAIN1650
DATA Z10/262*0.0/                                                       MAIN1660
DATA Z11/7*0.0/                                                         MAIN1670
DATA Z12/8*0.0/                                                         MAIN1680
DATA Z13/6*0.0/                                                         MAIN1690
DATA Z14/2*0.0/                                                         MAIN1700
DATA Z15/6*0.0/                                                         MAIN1710
DATA Z16/38*0.0/                                                        MAIN1720
DATA Z17/13*0.0/                                                        MAIN1730
DATA Z18/62*0.0/                                                        MAIN1740
DATA Z19/62*0.0/                                                        MAIN1750
DATA Z20/11*0.0/                                                        MAIN1760
DATA Z21/7*0.0/                                                         MAIN1770
DATA Z22/4*0.0/                                                         MAIN1780
DATA Z23/817*0.0/                                                       MAIN1790
DATA Z24/36*0.0/                                                        MAIN1800
DATA Z25/55*0.0/                                                        MAIN1810
DATA Z26/12*0.0/                                                        MAIN1820
DATA Z27/4*0.0/                                                         MAIN1830
DATA Z28/4*0.0/                                                         MAIN1850
```

```fortran
      DATA Z28A/4*0.0/                                                  MAIN1870
      DATA Z29/5*0.0/                                                   MAIN1880
      DATA Z30/12*0.0/                                                  MAIN1890
      DATA Z31/2*0.0/                                                   MAIN1900
      DATA Z32/0.0/                                                     MAIN1910
      DATA Z33/2*0.0/                                                   MAIN1920
      DATA Z34/62*0.0/                                                  MAIN1930
      DATA Z35/22*0.0/                                                  MAIN1940
      DATA Z36/19*0.0/                                                  MAIN1950
      DATA Z37/19*0.0/                                                  MAIN1960
      DATA Z38/5*0.0/                                                   MAIN1970
      DATA Z39/2*0.0/                                                   MAIN1980
      DATA Z40/20*0.0/                                                  MAIN1990
      DATA Z41/40*0.0/                                                  MAIN2000
      DATA Z42/80*0.0/                                                  MAIN2010
      DATA Z43/40*0.0/                                                  MAIN2020
      DATA Z44/4*0.0/                                                   MAIN2030
      END                                                               MAIN2040


      SUBROUTINE AEROD                                                  AER 0020
      INTEGER ON                                                        AER 0030
      COMMON /FAERO/ FX,FY,FZ,FK,FM,FN                                  AER 0040
      COMMON /FAIR/ RHOA,XLAERO                                         AER 0050
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  AER 0060
     -IRUD,IPROP,IAEROD,IRHS                                            AER 0070
      COMMON /VARBLE/ VAL(40)                                           AER 0080
                                                                        AER 0090
      EQUIVALENCE              (VAL(2),U),(VAL(3),V),(VAL(4),W),         AER 0100
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     AER 0110
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),AER 0120
     3(VAL(24),PB)                                                      AER 0130
      QA=RHOA*U*U                                                       AER 0140
      QAL=QA*XLAERO                                                     AER 0150
      BETA=-V/U                                                         AER 0160
      BETASQ=BETA*BETA                                                  AER 0170
      FX=-(0.90*BETASQ+0.13)*QA                                         AER 0180
      FY=(0.0*BETASQ+0.53*BETA)*QA                                      AER 0190
      FZ=-(2.06*BETASQ+0.39)*QA                                         AER 0200
      FK=-(0.5*BETASQ+0.0*BETA)*QAL                                     AER 0210
      FM=(0.29*BETASQ+0.12)*QAL                                         AER 0220
      FN=(0.0*BETASQ+0.076*BETA)*QAL                                    AER 0230
                                                                        AER 0240
      IF (IAEROD.NE.ON) RETURN                                          AER 0250
      WRITE(6,100) FX,FY,FZ,FK,FM,FN                                    AER 0260
  100 FORMAT(/10X,22HAEROD FX,FY,FZ,FK,FM,FN/6E15.4)                    AER 0270
      RETURN                                                            AER 0280
      END                                                               AER 0290
```

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```
      SUBROUTINE BOWSL                                              BWSL0010
      INTEGER ON                                                   BWSL0020
      COMMON /AIR/ PINF,RHOINF,GAM                                 BWSL0030
      COMMON /CONST/ PI,RAD,UO                                     BWSL0040
      COMMON / FORBS/ FX,FY,FZ,FK,FM,FN,QL                         BWSL0050
      COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM   BWSL0060
     1,DELS(4,10),XCP,ZCP                                          BWSL0070
      COMMON/GEOMBS/DETABX(11),DETABT(11),ARM1B(10),ARM2B(10)      BWSL0080
     1 ,DFBS(10),ISKIB(10)                                         BWSL0090
      COMMON/LEAKER/ALEAK,BLEAK,CFSS,CFBS                          BWSL0100
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  BWSL0110
     -IROD,IPROP,IAEROD,IRHS                                       BWSL0120
      COMMON /MASSES/ AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO  BWSL0130
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,ISINSL,IWAVES,    BWSL0140
      COMMON/SLOPE/WATSLP,XPWV,XLXPWV,XFWVXS                       BWSL0150
      COMMON/SUFTRS/XBF,PBS,SINBS,COSBS,X3S,Z3S,DELYBS,DP3S,ELMAXB,YAVG BWSL0160
     18(10)                                                        BWSL0170
      COMMON /VARBLE/ VAL(40)                                      BWSL0180
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,EETA,   BWSL0190
     1              FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV,           BWSL0200
     2              ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR      BWSL0210
      DIMENSION GAP(11),ELSKI(11)                                  BWSL0220
      DIMENSION WTAB(6),ZTAB(6)                                    BWSL0230
      DATA NPTS,IB/6,0/                                            BWSL0240
      DATA WTAB/0.3,.75,.5,.42,.6,.67,.5,8.42/                     BWSL0250
      DATA ZTAB/3.75,4.00,4.42,4.83,5.25,5.67/                     BWSL0260
      DATA ENU,UWSKI,CLSKI/1.28E-05,0.0,1.5708/                    BWSL0270
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),  BWSL0280
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),  BWSL0290
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),  BWSL0300
     3(VAL(24),PB)                                                 BWSL0310
      DO 5 J=1,11                                                  BWSL0320
      GAP(J)=0.0                                                   BWSL0330
      ELSKI(J)=0.0                                                 BWSL0340
    5 CONTINUE                                                     BWSL0350
      ALBS=0.0                                                     BWSL0360
      FX=0.0                                                       BWSL0370
      FZ=0.0                                                       BWSL0380
      FK=0.0                                                       BWSL0390
      FM=0.0                                                       BWSL0400
      FN=0.0                                                       BWSL0410
      DELPBG=PBS-PB                                                BWSL0420
      IF(DELPBG.LT.0.0) DELPBG=0.0                                 BWSL0430
      PPBAK=PB-PINF                                                BWSL0440
      DELP=PB-PBAR                                                 BWSL0450
      IF(DELP.LT.0.0)DELP=0.0                                      BWSL0460
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```
      SINDIF=SINBS-COSBS*THETA                                          BWSL0470
      COSDIF=COSBS+SINBS*THETA                                          BWSL0480
      X1=XBS+ZBS*THETA-XBF*SINDIF                                       BWSL0490
      Z1=-Z-ZBS+XBS*THETA-XBF*COSDIF                                    BWSL0500
      N=NSTA(3)                                                         BWSL0510
      DO 10 K=1,N                                                       BWSL0520
      ELSKI(K)=(ETA(3,K)-DETABX(K)*(XX(3,K)-X1)-Z1)+YY(3,K)*PHI         BWSL0530
     1+XLXPWV*WATSLP                                                    BWSL0540
      GAP(K)=-ELSKI(K)                                                  BWSL0550
      IF(GAP(K).LT.0.0) GAP(K)=0.0                                      BWSL0560
   10 CONTINUE                                                          BWSL0570
      N=NSTA(3)-1                                                       BWSL0580
      DO 20 J=1,N                                                       BWSL0590
      ELSKIA=(ELSKI(J+1)+ELSKI(J))/2.0                                  BWSL0600
      IF(ELSKIA.LE.0.0) GO TO 15                                        BWSL0610
      IF(ELSKIA.GT.ELMAXB) ELSKIA=ELMAXB                               BWSL0620
      ARMIB(J)=XX(3,J)+ELSKIA/2.0                                       BWSL0630
      ARM2B(J)=ZS-ELP*ELSKIA                                            BWSL0640
      DFBS(J)=-DELP*ELSKIA*DELYBS                                       BWSL0650
      ARG=0.5*RHO*U*U*ELSKIA*DELYBS                                     BWSL0660
      RESKI=U*ELSKIA/ENU                                                BWSL0670
      CDTSKI=0.427/(ALOG10(RESKI)-0.407)**2.64                          BWSL0680
      TSKIB(J)=-ARG*CDTSKI                                              BWSL0690
      GO TO 18                                                          BWSL0700
   15 DFBS(J)=0.0                                                       BWSL0710
      TSKIB(J)=0.0                                                      BWSL0720
   18 CONTINUE                                                          BWSL0730
      FX=FX+TSKIB(J)                                                    BWSL0740
      FZ=FZ+DFBS(J)                                                     BWSL0750
      FK=FK+DFBS(J)*YAVGB(J)                                            BWSL0760
      FM=FM-DFBS(J)*ARMIB(J)+TSKIB(J)*ARM2B(J)                          BWSL0770
      FN=FN-TSKIB(J)*YAVGB(J)                                           BWSL0780
      ALBS=ALBS+(GAP(J)+GAP(J+1))*DELYBS/2.0                            BWSL0790
   20 CONTINUE                                                          BWSL0800
      ALBS=ALBS+BLEAK                                                   BWSL0810
      QL=CFBS*ALBS*SQRT(2.0*ABS(PBAR)/RHOINF)*SIGN(1.0,PBAR)            BWSL0820
      IF(IBOWSL.NE.ON) RETURN                                           BWSL0830
      WRITE(6,100) GAP,ELSKI,FX,FY,FZ,FK,FM,FN                          BWSL0840
  100 FORMAT(//10X,8HBOW SEAL /26H GAP (FT.)(PORT TO STBD.) /11F10.5    BWSL0850
     1/28H ELSKI(FT.) (PORT TO STBD.) /11F10.5 /10X,23HBOWSL FX,FY,FZ,FBWSL0860
     2K,FM,FN /6E15.4)                                                  BWSL0870
      RETURN                                                            BWSL0880
      END                                                               BWSL0890

      SUBROUTINE COLFIL                                                 CFL 0020
      COMMON/AXIS/NXYS(26)                                              CFL 0070
      COMMON/COLUMN/IVERT,ILATRL                                        CFL 0080
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```
      COMMON /CURVE/ NCURV(10)                                          CFL 0090
      COMMON /EQNCO/ NEQS,TOL(20),JQQ                                   CFLL0100
      COMMON /GRAF/ NGRAF,NDRW                                          CFLL0110
      COMMON /HEADG/ TICRD(6)                                           CFLL0120
      COMMON /STEP/ STEP2                                               CFLL0130
      COMMON /SUM/ ISUM1(8),ISUM2(8)                                    CFLL0140
      REAL*8 TICRD                                                      CFLL0150
      REAL LABEL(4)/ 1',' 2',' 3'/                                      CFLL0160
      REAL*8 NAMES(52)/                                                 CFLL0170
     1 ' TIME     ',' WAVE HEIGHT ',' Z DIC                             CFLL0180
     2 ' PITCH ANGLE ',' PLENUM PRESSURE ',' BOW                        CFLL0190
     3 ' C.G.-ACCELERATION ',' FAN POWER ',' ROL                       CFLL0200
     4 ' YAW ANGLE ',' LAT ACCELERATION ',' SPEC                        CFLL0210
     5 ' TURN RADIUS ',' TURN RATE IN ',' X                            CFLL0220
     6 ' Y DISPLACEMENT ',' AIR FLOW ',' AIR                           CFLL0230
     7 ' NET FORCE X DIR ',' WAVE FORCE X DIR ',' NET                   CFLL0240
     8 ' NET FORCE Z DIR ',' NET TORQ ',' NET                          CFLL0250
       ' NET TORQUE Y AXIS ',' RUDDER ANGLE '/                         CFLL0260
      REAL*8 TITLE(12)                                                  CFLL0270
      REAL*8 LINE2(4),' PLOT IS ',' VERSUS '/                           CFLL0280
      REAL*8 NAMEX(2),NAMEY(2),INAME(16)                                CFLL0290
      EQUIVALENCE (TITLE(1),TICRD(1)),(TITLE(2),TICRD(2)),(TITLE(3),TI  CFLL0300
     1CRD(3)),(TITLE(4),TICRD(4)),(TITLE(5),TICRD(5)),(TITLE(6),TICRD(  CFLL0310
     26))                                                               CFLL
      DIMENSION PVQQ(26),XOUT(900),YOUT(900),AFILE(8)                   CFLL0340
      EQUIVALENCE (PVQQ(1),TIME),(PVQQ(2),ETA),(PVQQ(3),Z),(PVQQ(4),THETCFLL0350
     1A),(PVQQ(5),PB),(PVQQ(6),PHI),(PVQQ(7),ACC),(PVQQ(8),FANPWR),(PVQQCFLL0360
     2(9),PHI),(PVQQ(10),BETAS),(PVQQ(11),X),(PVQQ(12),U),(PVQQ(13),QIN)CFLL0370
     3(PVQQ(14),R),(PVQQ(15),Y),(PVQQ(16),Y),(PVQQ(17),QIN),(PVQQ(18),  CFLL0380
     4(PVQQ(18),QOUT),(PVQQ(19),GFXXX),(PVQQ(20),FXPWAV),(PVQQ(21),GF2),CFLL0390
     5(PVQQ(22),GF3),(PVQQ(23),GF4),(PVQQ(24),GF5),(PVQQ(25),GF6),       CFLL0400
     6(PVQQ(26),DELRS)                                                  CFLL0410
      IF(JQQ.NE.2) GO TO 1                                              CFLL0420
      WRITE(6,777) STEP2                                                CFLL0430
  777 FORMAT('0',4X,'THIS RUN USED VARIABLE STEP SIZE',/,'0',4X,'THE MINCFLL0440
     1IMUM STEPSIZE RECORDED DURING THE RUN WAS',2X,E30.5)              CFLL0450
      REWIND 1                                                          CFLL0460
    1 TITLE(7)=LINE2(1)                                                 CFLL0470
      TITLE(10)=LINE2(2)                                                CFLL0480
      IF(NGRAF.EQ.0) GO TO 11                                           CFLL0490
      J=1                                                               CFLL0500
      NCF=NGRAF                                                         CFLL0510
      INDEX=NGRAF*2                                                     CFLL0520
      DO 19 I=1,INDEX,2                                                 CFLL0530
      INDX=NXYS(I)                                                      CFLL0540
      INDY=NXYS(I+1)                                                    CFLL0550
      IQ=0                                                              CFLL0560
```

```
    7 READ(1,END=8)TIME,ETA,Z,THETA,PB,BONACC,ACC,FANPWR,PHI,BETAS,ACCLACFL 0570
   1T,U,TRADUS,R,X,Y,QIN,QOUT,GFXXX,FXFWAV,GF2,GF3,GF4,GF5,GF6,DELRS     CFL 0580
     IF(IQ.GE.900) GO TO 8                                              CFL 0590
     IQ=IQ+1                                                            CFL 0600
     XOUT(IQ)=PVQQ(INDX)                                                CFL 0610
     YCUT(IQ)=PVQQ(INDY)                                                CFL 0620
     GO TO 7                                                            CFL 0630
   8 REWIND 1                                                           CFL 0640
     INX=INDX*2                                                         CFL 0650
     INY=INDY*2                                                         CFL 0660
     NAMEX(1)=NAMES(INX-1)                                              CFL 0670
     NAMEX(2)=NAMES(INX)                                                CFL 0680
     NAMEY(1)=NAMES(INY-1)                                              CFL 0690
     NAMEY(2)=NAMES(INY)                                                CFL 0700
     IF(NORW.EQ.1) GO TO 20                                             CFL 0710
     CALL PLOTP(XOUT,YOUT,-IQ,0)                                        CFL 0720
     WRITE(6,301) NAMEX,NAMEY                                           CFL 0730
 301 FORMAT(' ',20X,2A8,' IS THE INDEPENDENT VARIABLE AND ',2A8,' THE DCFL 0740
   1EPENDENT VARIABLE.')                                                CFL 0750
     GO TO 19                                                           CFL 0760
  20 TITLE(5)=NAMEY(1)                                                  CFL 0770
     TITLE(9)=NAMEY(2)                                                  CFL 0780
     TITLE(11)=NAMEX(1)                                                 CFL 0790
     TITLE(12)=NAMEX(2)                                                 CFL 0800
     NCUR=NCURV(J)                                                      CFL 0810
     IF(NCUR.NE.0) GO TO 25                                             CFL 0820
     LABEL=LAB(1)                                                       CFL 0830
     CALL DRAW(IQ,XOUT,YOUT,NCUR,0,LABEL,TITLE,0,0,0,0,0,8,8,0,LAST)    CFL 0840
     J=J+1                                                              CFL 0850
     GO TO 19                                                           CFL 0860
  25 WRITE(2)IQ,NCUR,NGF,LABEL,(TITLE(K),K=1,12),(XOUT(L),YOUT(L),L=1,ICFL 0870
   1Q)                                                                  CFL 0880
     NGF=NGF-1                                                          CFL 0890
  19 CONTINUE                                                           CFL 0900
     IF((NGF.EQ.0).AND.(NCUR.EQ.3)) GO TO 26                            CFL 0910
  11 IF(IVERT.NE.1) GO TO 14                                            CFL 0920
     WRITE(6,100)                                                       CFL 0930
 100 FORMAT('0',50X,'***SUMMARY ONE***',/,'0')                          CFL 0940
     K=0                                                                CFL 0950
     DO 31 I=1,8                                                        CFL 0960
     IF(ISUMI(I).NE.0) K=K+1                                            CFL 0970
  31 CONTINUE                                                           CFL 0980
     NUM1=K                                                             CFL 0990
     IF(K.EQ.0) GO TO 14                                                CFL 1000
     N=K*2                                                              CFL 1010
     J=1                                                                CFL 1020
     DO 33 I=1,NUM1                                                     CFL 1030
     IDEX=ISUMI(I)*2                                                    CFL 1040
```

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```
      INAME(J)=NAMES(IDEX-1)
      INAME(J+1)=NAMES(IDEX)
      J=J+2
33    CONTINUE
300   WRITE(6,300)(INAME(I),I=1,N)
      FORMAT('0',16A8)
26    GO TO 4
      ENDFILE 2
      REWIND 2
      NGF=NGRAF
27    J=1
      READ(2,END=38)IQ,NCUR,NGRAF,LABEL,(TITLE(K),K=1,12),(XOUT(L),YOUT(
1L),L=1,IQ)
      IF((NGF.EQ.NGRAF).AND.(NCUR.EQ.J)) GO TO 29
      GO TO 27
29    LABEL=LAB(J+1)
      CALL DRAW(IQ,XOUT,YOUT,NCUR,0,LABEL,TITLE,0,0,0,0,0,8,8,0,LAST)
      REWIND 2
      J=J+1
      IF(J.EQ.4) GO TO 38
      GO TO 27
38    NGF=NGF-1
      IF(NGF.EQ.0) GO TO 11
      J=1
      GO TO 27
4     READ(1,END=13)(PVQQ(I),I=1,26)
      DO 35 I=1,NUM1
      J=ISUM1(I)
35    AFILE(I)=PVQQ(J)
      WRITE(6,400)(AFILE(I),I=1,NUM1)
400   FORMAT('0',8(3X,F10.2,3X))
      GO TO 4
13    REWIND 1
14    IF(ILATRL.NE.1) GO TO 17
      WRITE(6,200)
200   FORMAT('0',50X,'***SUMMARY TWO***',/,'0')
      K=0
      DO 32 I=1,8
      IF(ISUM2(I).NE.0) K=K+1
32    CONTINUE
      NUM2=K
      IF(K.EQ.0) GO TO 16
      N=K*2
      J=1
      DO 34 I=1,NUM2
      IDEX=ISUM2(I)*2
      INAME(J)=NAMES(IDEX-1)
      INAME(J+1)=NAMES(IDEX)
```

```
34    J=J+2
      CONTINUE
      WRITE(6,300)(INAME(I),I=1,N)
23    READ(1,END=16)(PVQQ(I),I=1,26)
      DO 36 I=1,NUM2
      J=ISUM2(I)
36    AFILE(I)=PVQQ(J)
      WRITE(6,400)(AFILE(I),I=1,NUM2)
      GO TO 23
16    REWIND 1
17    RETURN
      END
```

```
C
      SUBROUTINE DMINV (A,N,D)
      DIMENSION A(6,6),PIVOT(6)
      DIMENSION IPVOT(6),INDEX(6,2)
      EQUIVALENCE (IROW,JROW),(ICOL,JCOL)
      D=1.0
      DO 17 J=1,N
17    IPVOT(J)=0
      DO 135 I=1,N
      T=0.0
      DO 9 J=1,N
      IF(IPVOT(J)-1) 13,9,13
13    DO 23 K=1,N
      IF(IPVOT(K)-1) 43,23,81
43    IF(ABS(T)-ABS(A(J,K))) 83,23,23
83    IROW=J
      ICOL=K
      T=A(J,K)
23    CONTINUE
9     CONTINUE
      IPVOT(ICOL)=IPVOT(ICOL)+1
      IF(IROW-ICOL) 73,109,73
73    D=-D
      DO 12 L=1,N
      T=A(IROW,L)
      A(IROW,L)=A(ICOL,L)
12    A(ICOL,L)=T
109   INDEX(I,1)=IROW
      INDEX(I,2)=ICOL
      PIVOT(I)=A(ICOL,ICOL)
      D=D*PIVOT(I)
      A(ICOL,ICOL)=1.0
```

CFL 1530
CFL 1540
CFL 1550
CFL 1560
CFL 1570
CFL 1580
CFL 1590
CFL 1600
CFL 1610
CFL 1620
CFL 1630
CFL 1640

DMV 0010
DMV 0020
DMV 0030
DMV 0040
DMV 0050
DMV 0060
DMV 0070
DMV 0080
DMV 0090
DMV 0100
DMV 0110
DMV 0120
DMV 0130
DMV 0140
DMV 0150
DMV 0160
DMV 0170
DMV 0180
DMV 0190
DMV 0200
DMV 0210
DMV 0220
DMV 0230
DMV 0240
DMV 0250
DMV 0260
DMV 0270
DMV 0280
DMV 0290
DMV 0300
DMV 0310
DMV 0320
DMV 0330
DMV 0340

```
      DO 205 L=1,N
      A(ICOL,L)=A(ICOL,L)/PIVOT(I)
205   CONTINUE
      DO 134 LI=1,N
      IF(LI-ICOL) 21,134,21
21    T=A(LI,ICOL)
      A(LI,ICOL)=0.0
      DO 89 L=1,N
      A(LI,L)=A(LI,L)-A(ICOL,L)*T
89    CONTINUE
134   CONTINUE
135   DO 3 I=1,N
      L=N-I+1
19    IF(INDEX(L,1)-INDEX(L,2)) 19,3,19
      JROW=INDEX(L,1)
      JCOL=INDEX(L,2)
      DO 549 K=1,N
      T=A(K,JROW)
      A(K,JROW)=A(K,JCOL)
      A(K,JCOL)=T
549   CONTINUE
3     CONTINUE
81    RETURN
      END
```

```
      SUBROUTINE FAN
      INTEGER ON
      COMMON /AIR/ PINF,RHOINF,GAM
      COMMON /FANMAP/QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,
     1 ,ENSFAN,BRPM,EMRPM,SRPM,NPTSB,NPTSM,NPTSS
     2 ,PBFAN(25),PMFAN(25),PSFAN(25),TMEB(25),DELB(25),NB,TMES(25),
     3DELS(25),NS
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,
     -IKUD,IPROP,IAEROD,IRHS
      COMMON/SOFTBS/XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVG
     1B(10)
     1 COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS
     1,LLMAXS,YAVGS(10)
     1 COMMON /VARBLE/ VAL(40)
      DIMENSION QB(1),QM(1),QS(1),PBOW(1),PM(1),PS(1)
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),
     3(VAL(24),P6)
      EQUIVALENCE (VAL(18),FANPWR)
```

C

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```
      EQUIVALENCE (QBFAN(1),QB(1)),(QMFAN(1),QM(1)),(QSFAN(1),QS(1)),     FAN 0220
     1 (PBFAN(1),PBOW(1)),(PMFAN(1),PM(1)),(PSFAN(1),PS(1))               FAN 0230
                                                                          FAN 0240
      BRAT=3000/BRPM                                                      FAN 0250
      EMRAT=3000/EMRPM                                                    FAN 0260
      SRAT=3000/SRPM                                                      FAN 0270
      TL=VAL(1)                                                           FAN 0280
      IF(NB.EQ.0.0) GO TO 5                                               FAN 0290
      DPBS=FGI(TL,NB,TMEB,DELB,ILB)                                       FAN 0300
      PBS=PB+DPBS                                                         FAN 0310
    5 IF(NS.EQ.0.0) GO TO 6                                               FAN 0320
      DPSS=FGI(TL,NS,TMES,DELS,ILS)                                       FAN 0330
      PSS=PB+DPSS                                                         FAN 0340
    6 CONTINUE                                                            FAN 0350
      PB1=PBS-PINF                                                        FAN 0360
      PB2=PB-PINF                                                         FAN 0370
      PB3=PSS-PINF                                                        FAN 0380
      PBARB=PB1*BRAT**2                                                   FAN 0390
      PBARM=PB2*EMRAT**2                                                  FAN 0400
      PBARS=PB3*SRAT**2                                                   FAN 0410
                                                                          FAN 0420
      QBOW=ENBFAN*FGI(PBARB,NPTSB,PBOW,QB,IB)/BRAT                        FAN 0430
      QMAIN=ENMFAN*FGI(PBARM,NPTSM,PM,QM-IM)/EMRAT                        FAN 0440
      QSTN=ENSFAN*FGI(PBARS,NPTSS,PS,QS,IS)/SRAT                          FAN 0450
      QIN=QBOW+QMAIN+QSTN                                                 FAN 0460
      FANPWR=(QBOW*PB1+QMAIN*PB2+QSTN*PB3)/550.                           FAN 0470
      IF(IRHS.NE.ON) RETURN                                              FAN 0480
  100 WRITE(6,100) QBOW,QMAIN,QSTN,PBARB,PBARM,PBARS                      FAN 0490
    1 FORMAT(/4H FAN /32H Q - BOW,MAIN,STERN (CU FT /SEC) 3F12.1          FAN 0500
     1 /28H DELP - BOW,MAIN,STERN (PSF) 3F11.2)                           FAN 0510
      RETURN                                                              FAN 0520
      END                                                                 FAN 0530

      FUNCTION FGI(X,N,XT,YT,IX)                                          FGI 0010
      DIMENSION XT(1),YT(1)                                               FGI 0020
      IF(IX.LT.1) IX=1                                                    FGI 0030
      IF(IX.GT.N-1) IX=N-1                                                FGI 0040
      I=SIGN(1.0,X-XT(IX))                                                FGI 0050
      IF(IX.LT.1.OR. IX.GE.N) GO TO 30                                    FGI 0060
      IF(XT(IX).GT.X .OR.X.GT.XT(IX+1)) GO TO 20                          FGI 0070
      C=(X-XT(IX))/(XT(IX+1)-XT(IX))                                      FGI 0080
      GO TO 100                                                           FGI 0090
   20 IX=IX+(                                                             FGI 0100
      GO TO 10                                                            FGI 0110
   30 C=IX/N                                                              FGI 0120
      IX=IX-I                                                             FGI 0130
C                                                                         FGI 0140
```

```
100   FG1=YT(IX)+C*(YT(IX+1)-YT(IX))
      RETURN
      END
C
      SUBROUTINE FORIT(FNT,N,M,A,B,IER)
      DIMENSION A(1),B(1),FNT(1)
C     CHECK FOR PARAMETER ERRORS
20    IER=0
      IF(M) 30,40,40
30    IER=2
      RETURN
40    IF(M-N) 60,60,50
50    IER=1
      RETURN
C     COMPUTE AND PRESET CONSTANTS
60    CONTINUE
      AN=N
      COEF=2.0/(2.0*AN+1.0)
      PI=4.*ATAN(1.)
      CONST=PI*COEF
      S1=SIN(CONST)
      C1=COS(CONST)
      C=1.0
      S=0.0
      J=1
      FNTZ=FNT(1)
70    U2=0.0
      U1=0.0
      I=2*N+1
C     FORM FOURIER COEFFICIENTS RECURSIVELY
75    U0=FNT(I)+2.0*C*U1-U2
      U2=U1
      U1=U0
      I=I-1
      IF(I-1) 80,80,75
80    A(J)=COEF*(FNTZ+ C*U1-U2)
      B(J)=COEF*S*U1
      IF(J-(N+1)) 90,100,100
90    Q=C1*C-S1*S
      S=C1*S+S1*C
      C=Q
      J=J+1
```

FG1 0150
FG1 0160
FG1 0170

FRT 0010
FRT 0020
FRT 0030
FRT 0040
FRT 0050
FRT 0060
FRT 0070
FRT 0080
FRT 0090
FRT 0100
FRT 0110
FRT 0120
FRT 0130
FRT 0140
FRT 0150
FRT 0160
FRT 0170
FRT 0180
FRT 0190
FRT 0200
FRT 0210
FRT 0220
FRT 0230
FRT 0240
FRT 0250
FRT 0260
FRT 0270
FRT 0280
FRT 0290
FRT 0300
FRT 0310
FRT 0320
FRT 0330
FRT 0340
FRT 0350
FRT 0360
FRT 0370
FRT 0380
FRT 0390
FRT 0400
FRT 0410
FRT 0420
FRT 0430

```
      GO TO 70                                                          FRT 0440
100   A(1)=A(1)*0.5                                                     FRT 0450
      RETURN                                                            FRT 0460
      END                                                               FRT 0470
                                                                        FRT 0480
      SUBROUTINE INCON (TIME)                                           INCN0010
      REAL*8 TICRD                                                      INCN0020
      INTEGER ON                                                        INCN0030
      COMMON /AIR/ PINF,RHOINF,GAM                                      INCN0040
      COMMON/AXIS/NXYS(26)                                              INCN0050
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IY INCN0060
      COMMON /COLUMN/ IVERT,ILATRL                                      INCN0070
      COMMON /CONST/ PI,RAD,UO                                          INCN0080
      COMMON /CNTRL/CONTW,CONTQ,CONTTH,QMULT,LOUVER,ACONTZ,ACONTW,ZEQUIL INCN0090
     1 ,THEQL,ACBASE                                                    INCN0100
      COMMON /CURVE/NCURV(10)                                           INCN0110
      COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,     INCN0120
     ATIP(25),TIS(25)                                                   INCN0130
      COMMON /EQNCO/ NEQS,TOL(20),JQQ                                   INCN0140
      COMMON /FAIR/ RHOA,XLAERO                                         INCN0150
      COMMON /FANMAP/ QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,  INCN0160
     1 ENSFAN,BKPM,EMRPM,NPTSB,NPTSM,NPTSS                              INCN0170
     2 ,PBFAN(25),PMFAN(25),PSFAN(25),TMEB(25),DELB(25),NB,TMES(25),    INCN0180
     3 DETS(25),NS                                                      INCN0190
      COMMON /FROUDE / FN,FNCRIT                                        INCN0200
      COMMON/GBOW/ X30W                                                 INCN0210
      COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM        INCN0220
     1 ,DELS(4,10),XCP,ZCP                                              INCN0230
      COMMON /GEOMSW/ XAVG(10),DS                                       INCN0240
      COMMON/GRAF/NGRAF,NDRW                                            INCN0250
      COMMON /HEADG/TICRD(6)                                            INCN0260
      COMMON /PWAVE/ FNCON,PWVCON                                       INCN0270
      COMMON /LEAKER/ ALEAK,BLEAK,CFSS,CFBS                             INCN0280
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  INCN0290
     1 AMI(201),AIXX(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO           INCN0300
      COMMON /MATRIX/ A(6,6)                                            INCN0310
      COMMON /OPTION/ I3DOF,ISRGE,ITRIM,NVALID                          INCN0320
      COMMON /PLENUM/XLBW,XBBW,ABW,BUBHGT                               INCN0330
      COMMON /PLVCQO/NVI,NLI,NLD                                        INCN0340
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                     INCN0350
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIOWL,IBOWSL,ISTNSL,IWAVES,  INCN0360
     -IRUD,IPRUD,IAERO,IRHS                                             INCN0370
      COMMON /ROLL/ PHIMAX,TROLL                                        INCN0380
      COMMON/RUDDK/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,  INCN0390
     ARCL8,RTC,RUDANG,TIR(25)                                          INCN0400
      COMMON /KISER/ AMPTC                                              INCN0410
```

```
      COMMON /SLOPE/WATSLP,XPWV,XLXPWV,XPWVXS                            INCN0420
     1CCMMCN/SOFTBS/XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVG   INCN0430
     1B(10)                                                              INCN0440
      COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS            INCN0450
     1 ,ELMAXS,YAVGS(10)                                                 INCN0460
      COMMON/SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSWINCN0470
     1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ ,AVBMSW,DELX,VTC        INCN0480
      COMMON /STABLE/ S(4),ISTAB                                        INCN0490
      COMMON /STSLR/ CPHI,CPHID                                          INCN0500
      COMMON/SUM/ ISUM1(3),ISUM2(8)                                      INCN0510
      COMMON /VALOLD/ YOLD(20)                                           INCN0520
      COMMON /VARBLE/ VAL(40)                                            INCN0530
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,         INCN0540
     1       FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                         INCN0550
     2       ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR                  INCN0560
      COMMON /WAVEF/WAVLEN(10),OMEGAF(10),WAVSLP(10),ENCPER(10)          INCN0570
      COMMON /WAVTAB/ NAL,SAL,NDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,           INCN0580
     1  AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),                 INCN0590
     2  AC5(20,5,7),AC6(20,5,7),AC7(20,5,7),                             INCN0600
     3  ACO(20,5,7),ACOO(20,5,7),AC8(20,5,7),                           INCN0610
     4  AS1(20,5,7),AS2(20,5,7),AS3(20,5,7),AS4(20,5,7),                 INCN0620
     5  AS5(20,5,7),AS6(20,5,7),AS7(20,5,7),                             INCN0630
     6  ,ASO(20,5,7),ASOO(20,5,7),AS8(20,5,7)                           INCN0640
     7  ,BB(36),XREF,RX                                                  INCN0650
      DIMENSION ZZZ(14050)                                               INCN0660
      EQUIVALENCE (ZZZ,NAL)                                              INCN0670
     1(VAL(5),P),(VAL(6),Q),     (VAL(2),U),(VAL(3),V),(VAL(4),W),        INCN0680
     2(VAL(10),Z),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),                INCN0690
     3(VAL(24),P3),     (VAL(21),X),(VAL(22),Y),(VAL(23),PSI),           INCN0700
      DIMENSION TEMP(7),XMO(10)                                          INCN0710
      DIMENSION TITLC(20)                                                INCN0720
      DATA BEAM,BFTAD,DELO,DELPI,DLRDO,DSO,ISYS,RMAXO,RONO,RRATO,RREVO,  INCN0730
     1 THETO,THSSI,TPRIND,UO,VXO,VZO,XBSI,XCPO,XLTOT,XPO,XRO,XSSI,YPO,    INCN0740
     2 ZPO,ZRO,ZSSI/ 6*0.0,0,20*0.0/                                     INCN0750
      DO 9 I=1,8                                                         INCN0760
      ISUM1(I)=0                                                         INCN0770
    9 ISUM2(I)=0                                                         INCN0780
      PINF=2116.                                                         INCN0790
      RHOINF=.002378                                                     INCN0800
      GAM=1.4                                                            INCN0810
      GO TO 10                                                           INCN0820
 2200 READ(5,3000) NGRAF,NDRW                                            INCN0830
 3000 FORMAT(2I2)                                                        INCN0840
      READ(5,3001) NXYS                                                  INCN0850
 3001 FORMAT(26I2)                                                       INCN0370
      READ(5,3002) TICRD                                                 INCN0880
                                                                         INCN0890
```

```fortran
3002  FORMAT(6A8)
10    READ(5,99) ISYSL,IOPT,(TEMP(I),I=1,7)
      IF( ISYSL .EQ. ISYS .AND. ISYSL.EQ. 13) GOTO 70
      ISYS=ISYSL
      IF((ISYS.LE.0).OR.(ISYS.GT.22)) GO TO 70
      GOTO(100,200,300,400,500,600,700,800,900,1000,1100,1200,1300,
     11400,1500,1600,1700,1800,1900,2000,2100,2200),ISYS
C
100   PROGRAM CONTROL PARAMETERS
      CONTINUE
      GOTO(101,102,103,104,105),IOPT
101   CONTINUE
      STIME=TEMP(1)
      FTIME=TEMP(2)
      DELO=TEMP(3)
      DELPNT=TEMP(4)
      TPRINQ=TEMP(5)
      IF(TPRINQ.LT.STIME+DELPNT) TPRINQ = STIME+DELPNT
      IF(DELO.GT.DELPNT) DELO=DELPNT
      IF(DELO.EQ.0.0) GO TO 140
      GOTO 10
2000  READ(5,3003) NCURV
3003  FORMAT(10I1)
      GOTO 10
2100  READ(5,2210) ISUM1
2210  READ(5,2210) ISUM2
      FORMAT(8I2)
      GOTO 10
102   READ(5,191) IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,IRUD,
     1IPROP,IAEROD,IRHS
      GOTO 10
103   READ(5,175) NEQS,JQQ,(TOL(J),J=1,NEQS)
      GOTO 10
104   READ(5,191) IVERT,ILATRL,NVD,NVI,NLD,NLI
      GOTO 10
105   CONTINUE
      IDOF=TEMP(1)
      ISRGE=TEMP(2)
      ITRIM=TEMP(3)
      GOTO 10
140   WRITE(6,195)
      STOP
C
200   MASS DISTRIBUTION
      G=32.17
      RHO=1.99
      HRHO=RHO/2.
      GO TO (210,220,230), IOPT
```

INCN0900
INCN0910
INCN0920
INCN0930
INCN0940
INCN0950
INCN0960
INCN0970
INCN0980
INCN0990
INCN1000
INCN1010
INCN1020
INCN1030
INCN1040
INCN1050
INCN1060
INCN1070
INCN1080
INCN1090
INCN1100
INCN1110
INCN1120
INCN1130
INCN1140
INCN1150
INCN1160
INCN1170
INCN1180
INCN1190
INCN1200
INCN1210
INCN1220
INCN1230
INCN1240
INCN1250
INCN1260
INCN1270
INCN1280
INCN1290
INCN1300
INCN1310
INCN1320
INCN1330
INCN1340
INCN1350
INCN1360
INCN1370

```fortran
210   IMM = 0
      WEIGHT = TEMP(1)
      AM = WEIGHT/G
      XS = -TEMP(2)
      ZS = TEMP(3)
      AIXX = TEMP(4)
      AIYY = TEMP(5)
      AIZZ = TEMP(6)
      AIXZ = TEMP(7)
C     INERTIA MATRIX OPERATIONS
212   DO 211 I=1,6
211   DO 211 N=1,6
      A(I,N) = 0.0
213   DO 213 N=1,3
      A(N,N)=AM
      A(4,4)=AIXX
      A(5,5)=AIYY
      A(6,6)=AIZZ
      A(4,6)=-AIXZ
      A(6,4)=-AIXZ
      AIMAX=AMAXI(AM,AIXX,AIYY,AIZZ,ABS(AIXZ))
214   DO 214 I=1,6
214   A(I,J)=A(I,J)/AIMAX
      CALL DMINV(A,6,D)
215   DO 215 I=1,6
215   DO 215 J=1,6
      A(I,J)=A(I,J)/AIMAX
      IF (D.NE.0.0) GO TO 10
      WRITE (6,216)
      STOP
C     READ WEIGHT DISTRIBUTION - ASSUME TRANSVERSE (PORT/STBD) SYMMETRY
C        X INPUT DIST. FWD. OF (SIDEWALL) TRANSOM
C        Y INPUT DIST. TO STARBOARD
C        Z INPUT DIST. UP FROM KEEL-LINE
220   I = 1
222   READ (5,192) AMI(I),XI(I),YI(I),ZI(I)
      IF (AMI(I).LT.0.0) GO TO 224
      I=I+1
      IF ( I .GT. 201 ) GO TO 70
      GO TO 222
224   NMASS = I-1
      SUM = 0.0
      SUX = 0.0
      SUZ = 0.0
      DO 225 I=1,NMASS
      AMI(I) = AMI(I)/G
      SUM = SUM+AMI(I)
```

```
225   SUX = SUX+AMI(I)*XI(I)                                 INCN1860
      SUZ = SUZ+AMI(I)*ZI(I)                                 INCN1870
      AM = SUM*2.0                                           INCN1880
      WEIGHT = AM*G                                          INCN1890
      ZS = SUZ/SUM                                           INCN1900
      XS = SUX/SUM                                           INCN1910
      SUM = 0.0                                              INCN1920
      SUX = 0.0                                              INCN1930
      SUY = 0.0                                              INCN1940
      SUZ = 0.0                                              INCN1950
      DO 226 I=1,NMASS                                       INCN1960
      XI(I) = XI(I)-XS                                       INCN1970
      ZI(I) = -ZI(I)+ZS                                      INCN1980
      AMK = AMI(I)*2.0                                       INCN1990
      SUX = SUX+AMK*XI(I)*XI(I)                              INCN2000
      SUY = SUY+AMK*YI(I)*XI(I)                              INCN2010
      SUZ = SUZ+AMK*ZI(I)*ZI(I)                              INCN2020
226   SUM = SUM+AMK*XI(I)*ZI(I)                              INCN2030
      AIXX = SUY+SUZ                                         INCN2040
      AIYY = SUX+SUZ                                         INCN2050
      AIZZ = SUX+SUY                                         INCN2060
      AIXZ = SUM                                             INCN2070
      GO TO 212                                              INCN2080
230   GO TO 10                                               INCN2090
C     XX AND YY  TABLES                                      INCN2100
300   CONTINUE                                               INCN2110
      NSTA(1) = TEMP(1)                                      INCN2120
      NSTA(2) = TEMP(2)                                      INCN2130
      NSTA(3) = TEMP(3)                                      INCN2140
      NSTA(4) = TEMP(4)                                      INCN2150
      XLIOT=TEMP(5)                                          INCN2160
      GOTO 10                                                INCN2170
C     SIDEWALL (INCLUDING APPENDAGES)                        INCN2180
400   CONTINUE                                               INCN2190
      GOTO (401,402),IOPT                                    INCN2200
401   YSW=TEMP(1)                                            INCN2210
      XLSW=TEMP(2)                                           INCN2220
      CFSW=TEMP(3)                                           INCN2230
      COSW=TEMP(4)                                           INCN2240
      AVBMSW=TEMP(5)                                         INCN2250
      READ (10) ZZZ                                          INCN2260
      REWIND 10                                              INCN2270
      GOTO 10                                                INCN2280
C     BLOCK 4 OPTION 2 REMOVED.     NO APENDAGES             INCN2290
402   CONTINUE                                               INCN2300
      GOTO 10                                                INCN2310
                                                             INCN2320
                                                             INCN2330
```

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C     STERNSEAL                                                   INCN2340
500   CONTINUE                                                    INCN2350
      XSSI=TEMP(1)                                                INCN2360
      ZSSI=TEMP(2)                                                INCN2370
      ALEAK=TEMP(3)                                               INCN2380
      CFSS=TEMP(4)                                                INCN2390
      THSSI=TEMP(5)                                               INCN2400
      DPSS=TEMP(6)                                                INCN2410
      XLF=TEMP(7)                                                 INCN2420
      SINTH=SIN(THSSI/RAD)                                        INCN2430
      COSTH=COS(THSSI/RAD)                                        INCN2440
      ELMAXS=XLF*COSTH                                            INCN2450
      GO TO 10                                                    INCN2460
C     BOWSEAL                                                     INCN2470
600   CONTINUE                                                    INCN2480
      XBSI=TEMP(1)                                                INCN2490
      CFBS=TEMP(2)                                                INCN2500
      DPBS=TEMP(3)                                                INCN2510
      ZBSI=TEMP(4)                                                INCN2520
      THBSI=TEMP(5)                                               INCN2530
      XBF=TEMP(6)                                                 INCN2540
      BLEAK=TEMP(7)                                               INCN2550
      SINBS=SIN(THBSI/RAD)                                        INCN2560
      COSBS=COS(THBSI/RAD)                                        INCN2570
      ELMAXB=XBF*COSBS                                            INCN2580
      GOTO 10                                                     INCN2590
C     PLENUM                                                      INCN2600
700   CONTINUE                                                    INCN2610
      GO TO(705,710),IOPT                                         INCN2620
705   CONTINUE                                                    INCN2630
      XLBW=TEMP(1)                                                INCN2640
      XBBW=TEMP(2)                                                INCN2650
      XPWV=TEMP(3)                                                INCN2660
      WIDTH=TEMP(4)                                               INCN2670
      XL=TEMP(5)                                                  INCN2680
      XCPU=TEMP(6)                                                INCN2690
      BUBHGT=TEMP(7)                                              INCN2700
      XLXPWV=XLBW-XPWV                                            INCN2710
      XPWVXS=XPWV-XS                                              INCN2720
      ABW=WIDTH*XLBW                                              INCN2730
      AB=XBBW*XL                                                  INCN2740
      VCLNUM=(ABW+AB)*BUBHGT/2.                                   INCN2750
      GOTO 10                                                     INCN2760
710   CONTINUE                                                    INCN2770
      FNCRIT=TEMP(1)                                              INCN2780
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         GO TO 10                                                   INCN2820
C        PROPULSION                                                 INCN2830
800      CONTINUE                                                   INCN2840
         GO TO (805,810),IOPT                                       INCN2850
805      CONTINUE                                                   INCN2860
         XPO=TEMP(1)                                                INCN2870
         YPO=TEMP(2)                                                INCN2880
         ZPO=TEMP(3)                                                INCN2890
         GO TO 10                                                   INCN2900
C BLOCK 8 OPTION 2 REMOVED. ENGINE OUT INPUT IN BLOCK 16            INCN2910
810      CONTINUE                                                   INCN2920
         GOTO 10                                                    INCN2930
C        RUDDER.                                                    INCN2940
900      CONTINUE                                                   INCN2950
         GO TO (905,910,915),IOPT                                   INCN2960
905      XRO = TEMP(1)                                              INCN2970
         YR = TEMP(2)                                               INCN2980
         ZRO = TEMP(3)                                              INCN2990
         RSPAN=TEMP(4)                                              INCN3000
         RASPR=TEMP(5)                                              INCN3010
         RAREA=TEMP(6)                                              INCN3020
         RCLB=2.*PI*RASPR/(RASPR+3.)                                INCN3030
         RIC=TEMP(7)                                                INCN3040
         GO TO 10                                                   INCN3050
C        910 NOT USED                                               INCN3060
910      CONTINUE                                                   INCN3070
         GO TO 10                                                   INCN3080
915      CONTINUE                                                   INCN3090
         GOTO 10                                                    INCN3100
C        AERODYNAMICS                                               INCN3110
1000     CONTINUE                                                   INCN3120
         XLAERO=TEMP(1)                                             INCN3130
         BEAM=TEMP(2)                                               INCN3140
         RHOA=.5*RHOINF*XLAERO*BEAM                                 INCN3150
         GOTO 10                                                    INCN3160
C        WAVES                                                      INCN3170
1100     CONTINUE                                                   INCN3180
         IWAVSW=IOPT                                                INCN3190
         NWAVE=TEMP(1)                                              INCN3200
         IF(NWAVE .EQ. 0) GOTO 10                                   INCN3210
         IF(NWAVE .GT. 10) GOTO 70                                  INCN3220
         BETAD=TEMP(2)                                              INCN3230
         BETA=BETAD/RAD                                             INCN3240
         COSBET=COS(BETA)                                           INCN3250
                                                                    INCN3260
                                                                    INCN3270
                                                                    INCN3280
                                                                    INCN3290
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      SINBET=SIN(BETA)                                                  INCN3300
      TC = 1.0                                                          INCN3310
      GOTO ( 1104,1106) ,IWAVSW                                         INCN3320
 1104 DO 1105 I=1,NWAVE                                                 INCN3330
 1105 READ(5,1190) OMEGA(I),AW(I)                                       INCN3340
      GOTO 10                                                           INCN3350
 1106 DO 1107 I=1,NWAVE                                                 INCN3360
 1107 READ (5,1190) WAVLEN(I) ,AW(I)                                    INCN3370
      GOTO 10                                                           INCN3380
C                                                                       INCN3390
C     INITIAL CONDITIONS                                                INCN3400
 1200 CONTINUE                                                          INCN3410
      UO = TEMP(1)                                                      INCN3420
      THETO = TEMP(2)                                                   INCN3430
      DSO = TEMP(3)                                                     INCN3440
      DELPI=TEMP(4)                                                     INCN3450
      GO TO 10                                                          INCN3460
C                                                                       INCN3470
 1300 CONTINUE                                                          INCN3480
C     INPUT COMPLETED.  PRINT ALL INPUT                                 INCN3490
      WRITE(6,2004) TITLC                                               INCN3500
      WRITE (6,2001) STIME,FTIME,DELO,TPRINO,DELPNT                     INCN3510
      WRITE (6,2002) IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,IRUD,INCN3520
    1 IPROP,IAERUD,IRHS                                                 INCN3530
      WRITE(6,2021) I3DOF,ISRGE,ITRIM,NVALID                            INCN3540
      WRITE(6,2191) WEIGHT,(TOL(J),J=1,NEQS)                            INCN3550
      WRITE(6,2171A,AIMAX,XS,ZS,AIXX,AIYY,AIZZ,AIXZ                     INCN3560
      WRITE(6,2018) NSTA                                                INCN3570
      WRITE(6,2490) YSW,XLSW,CFSW,CDSW,VANGLE,VSPAN,VCHORD,VXO,VY,VZO,   INCN3580
    1 AVBMSW,VTC                                                        INCN3590
      WRITE(6,2491) NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB      INCN3600
      IF (IM.GT.0) WRITE(6,1549)    (XMD(J),J=1,IMNX)                   INCN3610
      IMM,IMNX,IMNY, IBMFI,BTIME,IMT                                    INCN3620
      IF (IM1.GT.0) WRITE(6,1559) (YMI(J),J=1,IMNY)                     INCN3630
      WRITE(6,2010) XLBW,XBBW                                           INCN3640
      WRITE(6,2011) XL,WIDTH,XCPO,VOLNOM,BUBHGT                         INCN3650
      WRITE(6,2020) DELPI                                               INCN3660
      WRITE(6,2009) FNCRIT,XLTOT                                        INCN3670
      WRITE(6,2028) ENBFAN,BRPM,ENMFAN,EMRPM,ENSFAN,SRPM                INCN3680
      WRITE(6,2018) XRO,YR,ZRO,RONO,RMAKO,RRATO,RREVO,DLRDO             INCN3690
    1 RSPAN,RASPR,RAREA,RCLB,RTC                                        INCN3700
      WRITE(6,2012)       XPO,YPO,ZPO                                   INCN3710
      WRITE(6,2027) XLAERO,BEAM                                         INCN3723
      WRITE(6,2026) XBSI,CFBS,DPBS,ELMAKB                               INCN3730
      WRITE(6,2025) XSSI,ZSSI,ALEAK,CFSS,THSSI,DPSS,XLF                 INCN3740
      WRITE(6,2017) UO,THETO,DSO                                        INCN3750
```

```
C                    AND 2) INITIALIZE VARIABLES FOR CALCS.                    INCN3780
1302  DO 1302 I=1,40                                                           INCN3790
      VAL(I) = 0.0                                                             INCN3800
      U = UO*1.6878                                                            INCN3810
      XSS=-(XS-XSSI)                                                           INCN3820
      ZSS=ZS-ZSSI                                                              INCN3830
      THETA = THETO/RAD                                                        INCN3840
      THEQL=THETA                                                             INCN3850
      DS = DSO/12.                                                             INCN3860
      Z=-ZS+DS                                                                 INCN3870
      ZEQUIL=Z                                                                 INCN3880
      PHIMAX=0.                                                                INCN3890
      TROLL=0.                                                                 INCN3900
      IRDS=0                                                                   INCN3910
      TL=0.0                                                                   INCN3920
C     WAVE PARAMETERS TABLE                                                    INCN3930
      IF(NWAVE .EQ.0) GOTO 1321                                                INCN3940
      AMPTC=1.30287                                                            INCN3950
      GOTO(1310,1315),IWAVSW                                                   INCN3960
1310  DO 1311 I=1,NWAVE                                                        INCN3970
1311  WAVLEN(I)=2.*PI*G/(OMEGA(I)*OMEGA(I))                                    INCN3980
      GOTO 1317                                                                INCN3990
1315  DO 1316 I=1,NWAVE                                                        INCN3990
1316  OMEGA(I)=SQRT(2.*PI*G/WAVLEN(I))                                         INCN4010
1317  CONTINUE                                                                 INCN4020
C     CALCULATE INITIAL FREQUENCIES OF ENCOUNTER.                              INCN4030
      DO 1318 I=1,NWAVE                                                        INCN4040
      WAVSLP(I) = 360.0*AW(I)/WAVLEN(I)                                        INCN4050
      OMEGAE(I) =2.*PI*(SQRT(G*WAVLEN(I)/(2.*PI))-U*COSBET)/WAVLEN(I)          INCN4060
      ENCPER(I) = 2.0*PI/OMEGAE(I)                                             INCN4070
1318  CONTINUE                                                                 INCN4080
      WRITE (6,1191) NWAVE,BETAD,(OMEGA(I),OMEGAE(I),WAVLEN(I),AW(I),          INCN4090
     1               WAVSLP(I),ENCPER(I),I=1,NWAVE)                            INCN4100
      GOTO 1322                                                                INCN4110
1321  WRITE (6,1192)                                                          INCN4120
1322  CONTINUE                                                                 INCN4130
      DO 1303 I=1,4                                                            INCN4140
      DO 1303 N=1,11                                                           INCN4150
1303  ETA(I,N) = 0.0                                                           INCN4160
      DVOLW = 0.0                                                              INCN4170
      FXWAV = 00.000                                                           INCN4180
      FYWAV = 00.000                                                           INCN4190
      FZWAV = 00.000                                                           INCN4200
      FKWAV = 00.000                                                           INCN4210
      FMWAV = 0.0                                                              INCN4220
      ZBAR=Z                                                                   INCN4250
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PHIBAR=PHI                                              INCN4260
THEBAR=THETA                                            INCN4270
TIME=STIME                                              INCN4280
DELT = DELO                                             INCN4290
TPRINT=TPRINO-DELPNT                                    INCN4300
PWVCON=4.*WEIGHT/(RHO*G*XLBW)                           INCN4310
FNCON=SQRT(XLBW*G)                                      INCN4320
VX=VXO-XS                                               INCN4330
VZ = ZS-VZO                                             INCN4340
XP=XPO-XS                                               INCN4350
XR=XRO-XS                                               INCN4360
YP=YPO                                                  INCN4370
ZP=ZS-ZPO                                               INCN4380
ZR = ZS-ZRO                                             INCN4390
IF (IMM.EQ. 0) GO TO 1305                               INCN4400
DO 1304 J=1,IMNX                                        INCN4410
XMI(J) = XMO(J) - XS                                    INCN4420
1304 CONTINUE                                           INCN4430
1305 XCP = XCPO-XS                                      INCN4440
XCP = XCPO-XS                                           INCN4450
ZCP = ZS-BUBHGT                                         INCN4460
XBS=XBSI-XS                                             INCN4470
N=NSTA(3)                                               INCN4480
ZBS=ZS-ZBSI                                             INCN4490
DO 1364 J=1,N                                           INCN4500
DELYBS=XBBW/(N-1)                                       INCN4510
XBS=XBS-XSSI                                            INCN4520
XX(3,J)=-0.5*XBBW+(J-1)*DELYBS                          INCN4530
YY(3,J)=(YY(3,J+1)+YY(3,J))/2.                          INCN4540
N=N-1                                                   INCN4550
DO 1367 J=1,N                                           INCN4560
YAVGB(J)=(YY(3,J+1)+YY(3,J))/2.                         INCN4570
1367 CONTINUE                                           INCN4580
N=NSTA(4)                                               INCN4590
DELYSS=XBBW/(N-1)                                       INCN4600
DO 1365 J=1,N                                           INCN4610
XX(4,J)==-.5*XB3W+(J-1)*DELYSS                          INCN4620
YY(4,J)=-.5*XB3W+(J-1)*DELYSS                           INCN4630
1365 CONTINUE                                           INCN4640
N=N-1                                                   INCN4650
DO 1368 J=1,N                                           INCN4660
YAVGS(J)=(YY(4,J+1)+YY(4,J))/2.                         INCN4670
1368 CONTINUE                                           INCN4680
XBOW=XLTOT-XS                                           INCN4690
N=NSTA(1)                                               INCN4700
DELX=XBSI/(N-1)                                         INCN4710
DO 1309 J=1,N                                           INCN4720
DO 1309 I=1,2                                           INCN4730
XX(J,I)=(I-1)*DELX-XS
```

```
1309      YY(J,1) = YSW*(2*J-3)                                            INCN4740
          WRITE(6,1366) ((XX(J,N),N=1,11),(YY(J,N),N=1,11),J=1,4)          INCN4750
1366      FORMAT (//17H XX AND YY ARRAYS /14H PORT SIDEWALL /2(11F10.2/),  INCN4760
         1 15H STBD. SIDEWALL /2(11F10.2/),9H BOW SEAL /2(11F10.2/),       INCN4770
         2 11H STERN SEAL /2(11F10.2/))                                    INCN4780
          N=NSTA(1)-1                                                      INCN4790
          DO 1308 I=1,N                                                    INCN4800
1308      XAVG(I)=DELX*(2*I-1)/2.-XS                                       INCN4810
          CALL WAVES(TIME)                                                 INCN4820
C         INITIALIZE BUBBLE PRESSURE, ABSOLUTE (PSF)                       INCN4830
          PB=PINF+DELPI                                                    INCN4840
          PBBAR=DELPI                                                      INCN4850
          PBAR=DELPI                                                       INCN4860
          PSS=PB+DPSS                                                      INCN4870
          PBS=PB+DPBS                                                      INCN4880
          AB=ABW-(ABW-AB)*(ZS+Z/BUBHGT)                                    INCN4890
          CF=.37/((U/FNCON)**1.5655981)                                   INCN4900
          WATSLP=PBBAR*CF*PWVCON/WEIGHT                                    INCN4910
          VOL=VOLNOM-.5*(AB+ABW)*(Z+ZS)-DVOLW                              INCN4920
         1+.5*WATSLP*XL*AB                                                 INCN4930
          BMASS=(PB/PINF)**(1./GAM)*VOL*RHOINF                             INCN4940
          WRITE (6,2023)                                                   INCN4950
          RETURN                                                          INCN4960
C         RUN TERMINATOR                                                   INCN4970
1400      WRITE(6,98)                                                      INCN4980
          STOP                                                             INCN4990
C         BENDING MOMENT                                                   INCN5000
1500      GO TO (1510,1520,1530,1540), IOPT                                INCN5010
1510      IMM = TEMP(1)                                                    INCN5020
          IF (IMM.GT.3)          GO TO 70                                  INCN5030
          IMNX = TEMP(2)                                                   INCN5040
          IF (IMNX.GT.10)        GO TO 70                                  INCN5050
          IMNY = TEMP(3)                                                   INCN5060
          IF (IMNY.GT.7)         GO TO 70                                  INCN5070
          IBMFIL = TEMP(4)                                                 INCN5080
          BTIME = TEMP(5)                                                  INCN5090
          IF (IMM.EQ.3)     IMT = TEMP(6)                                  INCN5100
          GO TO 10                                                         INCN5110
1520      DO 1521 J=1,7                                                    INCN5120
1521      XMO(J) = TEMP(J)                                                 INCN5130
          IF(IMNX.LE.7) GO TO 10                                           INCN5140
          READ 1522, (XMO(J),J=8,IMNX)                                     INCN5150
          GO TO 10                                                         INCN5160
1530      DO 1531 J=1,IMNY                                                 INCN5170
1531      YMI(J) = TEMP(J)                                                 INCN5180
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      GO TO 10
 1540 CONTINUE                                                    INCN5220
      GO TO 10                                                     INCN5230
                                                                  INCN5240
 1600 CCNTINUE                                                    INCN5250
      GO TO(1605,1610,1615),IOPT                                  INCN5260
 1605 CONTINUE                                                    INCN5270
C     VALUES INPUT FOR STBD SCREW                                 INCN5280
      NPS=TEMP(1)                                                 INCN5290
      THST1=TEMP(2)                                               INCN5300
      STHS=TEMP(3)                                                INCN5310
      IF(NPS.EQ.0.0) GO TO 1609                                   INCN5320
      READ(5,1950)(TIS(J),J=1,NPS)                                INCN5330
      READ(5,1950)(THSTS(J),J=1,NPS)                              INCN5340
      GO TO 10                                                     INCN5350
 1609 THSTS(1)=THST1                                              INCN5360
 1610 CONTINUE                                                    INCN5370
C     VALUES INPUT FOR PORT SCREW                                 INCN5380
      THST2=TEMP(1)                                               INCN5390
      NPP=TEMP(2)                                                 INCN5400
      STHP=TEMP(3)                                                INCN5410
      IF(NPP.EQ.0.0) GO TO 1614                                   INCN5420
      READ(5,1950)(TIP(J),J=1,NPP)                                INCN5430
      READ(5,1950)(THSTP(J),J=1,NPP)                              INCN5440
      GO TO 10                                                     INCN5450
 1614 THSTP(1)=THST2                                              INCN5460
 1615 CONTINUE                                                    INCN5470
C     VALUES INPUT FOR RUDDER                                     INCN5480
      DELR=TEMP(1)                                                INCN5490
      NPR=TEMP(2)                                                 INCN5500
      IF(NPR.EQ.0.0) GO TO 1616                                   INCN5510
      READ(5,1950)(TIR(J),J=1,NPR)                                INCN5520
      READ(5,1950)(DELRUD(J),J=1,NPR)                             INCN5530
      GO TO 10                                                     INCN5540
 1616 DELRUD(1)=DELR                                              INCN5550
      GO TO 10                                                     INCN5560
                                                                  INCN5570
 1700 GO TO (1705,1710),IOPT                                      INCN5580
 1705 NB=TEMP(1)                                                  INCN5590
      READ(5,1950)(TMEB(I),I=1,NB)                                INCN5600
      READ(5,1950)(DELB(I),I=1,NB)                                INCN5610
      GO TO 10                                                     INCN5620
 1710 NS=TEMP(1)                                                  INCN5630
      READ(5,1950)(TMES(I),I=1,NS)                                INCN5640
      READ(5,1950)(DETS(I),I=1,NS)                                INCN5650
      GOTO 10                                                      INCN5660
                                                                  INCN5670
C     TITLE CARD (ALL 80 COLUMNS )                                INCN5680
                                                                  INCN5690
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1800  READ (5,2022) TITLC                                        INCN5700
      GO TO 10                                                   INCN5710
C                                                                INCN5720
1900  FAN MAPS                                                   INCN5730
      CONTINUE                                                   INCN5740
1905  GO TO (1905,1910,1915),IOPT                                INCN5750
      CONTINUE                                                   INCN5760
      ENBFAN=TEMP(1)                                             INCN5770
      BRPM=TEMP(2)                                               INCN5780
      NPTSB=TEMP(3)                                              INCN5790
      READIN=TEMP(4)                                             INCN5800
      IF (READIN .EQ. 0.0) GO TO 10                              INCN5810
      READ (5,1950) (PBFAN(J),J=1,NPTSB)                         INCN5820
      READ (5,1950) (QBFAN(J),J=1,NPTSB)                         INCN5830
      GO TO 10                                                   INCN5840
1910  CONTINUE                                                   INCN5850
      ENMFAN=TEMP(1)                                             INCN5860
      EMRPM=TEMP(2)                                              INCN5870
      NPTSM=TEMP(3)                                              INCN5880
      READIN=TEMP(4)                                             INCN5890
      IF (READIN .EQ. 0.0) GO TO 10                              INCN5900
      READ (5,1950) (PMFAN(J),J=1,NPTSM)                         INCN5910
      READ (5,1950) (QMFAN(J),J=1,NPTSM)                         INCN5920
      GO TO 10                                                   INCN5930
1915  CONTINUE                                                   INCN5940
      ENSFAN=TEMP(1)                                             INCN5950
      SRPM=TEMP(2)                                               INCN5960
      NPTSS=TEMP(3)                                              INCN5970
      READIN=TEMP(4)                                             INCN5980
      IF (READIN .EQ. 0.0) GO TO 10                              INCN5990
      READ (5,1950) (PSFAN(J),J=1,NPTSS)                         INCN6000
      READ (5,1950) (QSFAN(J),J=1,NPTSS)                         INCN6010
      GO TO 10                                                   INCN6020
1950  FORMAT(8F10.0)                                             INCN6030
C     ERROR IN INPUT                                             INCN6040
70    CONTINUE                                                   INCN6050
      WRITE (6,79) ISYS                                          INCN6060
      STOP                                                       INCN6070
79    FORMAT(34H INPUT ERROR - - STOP - - ISYS= ,I3)             INCN6080
98    FORMAT(1H1,20(/),50X,19H COMPLETED ALL RUNS )              INCN6090
191   FORMAT(I3,I2,7F10.0)                                       INCN6100
192   FORMAT(16I5)                                               INCN6110
195   FORMAT(5F10.0)                                             INCN6120
      FORMAT(//10X,6HERROR IN INPUT --- DELT AND/OR DELPNT EQUALS ZEROINCN6130
     1 --- JOB ABORTED )                                         INCN6140
175   FORMAT(2I2/(8F10.0))                                       INCN6150
216   FORMAT(//10X,82HERROR IN INPUT --- INPUT INERTIA ELEMENTS LEAD TOINCN6160
     1 ZERO DETERMINANT --- JOB ABORTED )                        INCN6170
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  217 FORMAT(22H INERTIA MATRIX, AIMAX   6E15.4/(22X,6E15.4))              INCN6180
  219 FORMAT(30H WEIGHT, C.G., INERTIA MOMENTS 7F12.3)                     INCN6190
  305 FORMAT( 11F7.0 )                                                     INCN6200
  490 FORMAT(15H SIDEWALL INPUT 12(F8.3,1X))                               INCN6210
  491 FORMAT(20H SIDEWALL TABLE PARAMETERS 4(I4,F7.3,F7.3))                INCN6220
 1190 FORMAT(2F10.0)                                                       INCN6230
 1191 FORMAT(/12H0NO OF WAVES 12,10H BETA(DEG)F5.0/15H OMEGA(RAD/SEC)      INCN6240
      15X,1H OMEGAE(RAD/SEC) 5X,16H WAVE LENGTH(FT) 5X,14H AMPLITUDE(FT)   INCN6250
      - 5X,16H MAX SLOPE (DEG)5X,13HPERIOD,E(SEC)/(F8.4,12X,F8.4,4F20.3))  INCN6260
 1192 FORMAT(/11H0CALM WATER)                                             INCN6270
 1519 FORMAT(/32H0MOMENT CALC. CONTROL PARAMETERS 4I5, F8.3, I5  )         INCN6280
      -      5X,/F10.0)                                                    INCN6290
 1522 FORMAT(22H MOMENT CALCS. AT X OF 11F10.3)                            INCN6300
 1559 FORMAT(22H MOMFNT CALCS. AT Y OF 11F10.3)                           INCN6310
 2004 FORMAT(33HISES MOTIONS AND LOADS PROGRAM - 20A4,/)                   INCN6320
 2001 FORMAT(23H START AND FINISH TIMES 2F10.2/                          INCN6330
      -22H INITIAL TIME INTERVAL F12.4/                                    INCN6340
      -18H START PRINTING AT F8.2,17H IN INCREMENTS OF F8.2)               INCN6350
 2002 FORMAT(24H INTERMEDIATE PRINT LAGS 16I5)                            INCN6360
 2039 FORMAT(39H NO. OF STATE EQUATIONS, AND TOLERANCES I5/(10X,10E12.2))  INCN6370
 2099 FORMAT(23HOCRITICAL FROUDE NUMBER F15.4,5X,19H TOTAL CRAFT LENGTH    INCN6380
      FI5.4)                                                               INCN6390
 2010 FORMAT(34HOPLENUM, LENGTH AND WIDTH AT WATER 2F12.4/                 INCN6400
 2011 FORMAT(34H PLENUM, LENGTH AND WIDTH AT HULL  2F12.4/                 INCN6410
      35H PLENUM, CENTER OF PRESSURE AT HULL F12.4/                       INCN6420
      -23H PLENUM, NOMINAL VCLUME F12.1,10X,6HHEIGHT F12.4/                INCN6430
 2012 FORMAT(/33H PROPULSION, X, Y, Z COORDINATES 3F12.4/                  INCN6440
 2013 FORMAT(/28H0RUDDER, ON, MAX,RATE, REVERSE, INITIAL  5F12.4/          INCN6450
      41H RUDDER, X, Y, Z COORDINATES 3F12.4/                             INCN6460
      33H RUDDER, SPAN,ASPECT, AREA,CLB,T/C  5F12.4/                      INCN6470
 2017 FORMAT(/39H0INITIAL CONDITIONS,-VELOCITY (KNOTS) = F7.2, 5X,         INCN6480
      13HPITCH (DEG) = F8.3,5X,12HDRAFT (IN) = F8.2)                      INCN6490
 2018 FORMAT(49H NUMBER OF STATIONS, SIDEWALLS (P+S) SEALS (B+S)  ,4I5)    INCN6500
 2020 FORMAT(58H PLENUM, INITIAL PRESSURE,GAGE (PSF) F8.2)                 INCN6510
 2021 FORMAT(/79H PROGRAM OPTION SWITCH SETTINGS (LATERAL PLANE,CONSTANT   INCN6520
      -SPEED,TRIM,VALIDATION) 4I5)                                        INCN6530
 2022 FORMAT(/20A4 )                                                       INCN6540
 2023 FORMAT( 1H1 )                                                        INCN6550
 2025 FORMAT( 16H STERNSEAL INPUT 7F12.4 )                                 INCN6560
 2026 FORMAT( 16H BOWSEAL INPUT 7F12.4 )                                   INCN6570
 2027 FORMAT( 19HOAERODYNAMICS INPUT 7F12.4)                               INCN6580
 2028 FORMAT( 33HOFANS, NO. + RPM, BOW,MAIN,STERN  3(F10.0,F10.1))         INCN6590
      END                                                                  INCN6600

      SUBROUTINE INTGRL (TIME)                                             INT 0020
      INTEGER ON                                                           INT 0030
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFKL,BTIME,IMT,XMI(10),YMI(7),IX,IYINT 0040
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      COMMON /EQNCO/ NEQS,TOL(20),JQQ                                    INT 0050
      COMMON /KSWTCH/ ITHRST                                             INT 0060
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,   INT 0070
     -                AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO        INT 0080
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                      INT 0090
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,   INT 0100
     -IRUD,IPROP,IAEROD,IRHS                                             INT 0110
      COMMON /STABLE/ S(4),ISTAB                                         INT 0120
      COMMON/STEP/ STEP2                                                 INT 0130
      COMMON /VALOLD / YOLD(20)                                          INT 0140
      COMMON /VARBLE/ VAL(40)                                           INT 0150
      EQUIVALENCE (VAL(1),X),(VAL(2),Y(1))                               INT 0160
      DIMENSION Y(20),ERROR(20)                                          INT 0170
      REAL K1(20),K2(20),K3(20),K4(20),K5(20)                           INT 0180
      DATA IPASS/0/                                                      INT 0190
      STEP2=1.0                                                          INT 0200
      PB=VAL(24)                                                         INT 0210
      BMASS=Y(10)                                                        INT 0220
    1 IF((TIME+DELT).LE.TPRINT) GO TO 12                                 INT 0230
      DELT=DELT                                                          INT 0240
      DELT=TPRINT-TIME                                                   INT 0250
      IPASS=1                                                            INT 0260
   12 X=TIME                                                             INT 0270
      DO 2 J=1,NEQS                                                      INT 0280
      Y(J)=YOLD(J)                                                       INT 0290
    2 CONTINUE                                                           INT 0300
      ITHRST=1                                                           INT 0310
      CALL RHS(K1)                                                       INT 0320
      ITHRST=2                                                           INT 0330
      IMT=0                                                              INT 0340
      IF (IACCEL.NE.ON) GO TO 14                                         INT 0350
      ACCLAT =(K1(2)+Y(1)*Y(6))/G                                        INT 0360
      WRITE (6,101) ACCLAT , DELT                                        INT 0370
   14 ON=2                                                               INT 0380
   15 H=DELT/3.                                                          INT 0390
      X=TIME+H                                                           INT 0400
      DO 3 J=1,NEQS                                                      INT 0410
    3 Y(J)=YOLD(J)+H*K1(J)                                               INT 0420
      CALL RHS(K2)                                                       INT 0430
      DO 4 J=1,NEQS                                                      INT 0440
    4 Y(J)=YOLD(J)+.5*H*(K1(J)+K2(J))                                    INT 0450
      CALL RHS(K3)                                                       INT 0460
      X=TIME+.5*DELT                                                     INT 0470
      DO 5 J=1,NEQS                                                      INT 0480
    5 Y(J)=YOLD(J)+.375*H*(K1(J)+3.*K3(J))                               INT 0490
      CALL RHS(K4)                                                       INT 0500
      X=TIME+DELT                                                        INT 0510
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6     DO 6 J=1,NEQS                                                      INT 0520
      Y(J)=YOLD(J)+.5*H*(3.*K1(J)-9.*K3(J)+12.*K4(J))                    INT 0530
      CALL RHS(K5)                                                       INT 0540
      IF(JQQ.EQ.1 ) GO TO 7                                              INT 0550
      DO 7 J=1,NEQS                                                      INT 0560
      ERROR(J)=(K1(J)-4.5*K3(J)+4.*K4(J)-.5*K5(J))*H/5.0                 INT 0570
      IF(ABS(ERROR(J)).GT.TOL(J)) GO TO 11                               INT 0580
7     CONTINUE                                                           INT 0590
      DO 105 J=1,NEQS                                                    INT 0600
      Y(J)=YOLD(J)+.5*H*(K1(J)+4.*K4(J)+K5(J))                           INT 0610
105   YOLD(J)=Y(J)                                                       INT 0620
      TIME=TIME+DELT                                                     INT 0630
      IF(IPASS.EQ.1) GO TO 8                                             INT 0640
      IF (JQQ.EQ.1 ) GO TO 10                                            INT 0650
      DO 75 J=1,NEQS                                                     INT 0660
      IF(ABS(ERROR(J)).GT.TOL(J)/16.) GO TO 9                            INT 0670
75    CONTINUE                                                           INT 0680
      DELT=2.*DELT                                                       INT 0690
      IF(DELT.GT.DELPNT) DELT=DELPNT                                     INT 0700
10    RETURN                                                             INT 0710
9     STEP2=DELT                                                         INT 0720
      GO TO 10                                                           INT 0730
8     DELT=DEL                                                           INT 0740
      IPASS=0                                                            INT 0750
      GO TO 10                                                           INT 0760
11    DELT=DELT/2.                                                       INT 0770
      IF(DELT.LT. 1.E-6 ) GO TO 25                                       INT 0780
      IF(JQQ.EQ.2) GO TO 26                                              INT 0790
      WRITE (6,666) TIME,DELT,J,ERROR(J),TOL(J)                          INT 0800
27    IPASS=0                                                            INT 0810
      GO TO 15                                                           INT 0820
26    STEP1=DELT*2.0                                                     INT 0830
      IF(STEP1.LT.STEP2)STEP2=STEP1                                      INT 0840
      GO TO 27                                                           INT 0850
25    WRITE ( 6,150 )  TIME,DELT,(K1(J),J=1,NEQS),VAL                    INT 0860
      WRITE (6,100) TIME,DELT,(K1(J),J=1,NEQS),VAL                       INT 0870
      STOP                                                               INT 0880
130   FORMAT(/10X,23HINTGRL TIME,DELT,K1,VAL /2E15.4/2(5E15.4/),5(8E15.4 INT 0890
     1/))                                                                INT 0900
101   FORMAT(1H0,9X,33HTOTAL LATERAL ACCELERATION (G) =   F12.4,         INT 0910
     112X,5HDT = E15.4)                                                  INT 0920
150   FORMAT(1H1,10X,44HDELTA TIME LESS THAN 1.0E-6  -  - JOB STOPS )    INT 0930
666   FORMAT(/10X,5HINT-J 2E30.5,I5,2E2C.5)                             INT 0940
      END                                                                INT 0950
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      SUBROUTINE PROP                                                   PROP0010
      INTEGER ON                                                        PROP0020
      COMMON /CONST/  PI,RAD,UO                                         PROP0030
      COMMON /FPROP/  FX,FY,FZ,FK,FM,FN                                 PROP0040
      COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,     PROP0050
     ATIP(25),TIS(25)                                                   PROP0060
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  PROP0070
     -IRUD,IPROP,IAEROD,IRHS                                            PROP0080
      COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,  PROP0090
     ARCLB,RTC,RUDANG,TIK(25)                                           PROP0100
      COMMON /VARBLE/ VAL(40)                                           PROP0110
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),       PROP0120
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     PROP0130
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),PROP0140
     3(VAL(24),PB)                                                      PROP0150
      DIMENSION THS(1),THP(1),TS(1),TP(1),RUD(1),TR(1)                  PROP0160
      EQUIVALENCE (THSTS(1),THS(1)),(THSTP(1),THP(1)),(TIS(1),TS(1)),(TIPROP0170
     AP(1),TP(1)),(TIR(1),TR(1)),(DELRUD(1),RUD(1))                     PROP0180
      FX = 0.0                                                          PROP0190
      FY = 0.0                                                          PROP0200
      FZ = 0.0000                                                       PROP0210
      FK = 0.0                                                          PROP0220
      FM = 0.                                                           PROP0230
      FN = 0.                                                           PROP0240
      TL=TIME                                                           PROP0250
      IF(NPR.EQ.0.0) GO TO 5                                            PROP0260
      RUDANG=FGI(TL,NPR,TR,RUD,IR)                                      PROP0270
      RUDANG=RUDANG/RAD                                                 PROP0280
C     CALCULATE THRUSTS AND MOMENTS INDIVIDUALLY                        PROP0290
      GO TO 6                                                           PROP0300
    5 RUDANG=DELRUD(1)                                                  PROP0310
      RUDANG=RUDANG/RAD                                                 PROP0320
    6 CO=COS(RUDANG)                                                    PROP0330
      SD=SIN(RUDANG)                                                    PROP0340
      IF(NPS.EQ.0.0) GO TO 2                                            PROP0350
      THSS=FGI(TL,NPS,TS,THS,IS)                                        PROP0360
      GO TO 4                                                           PROP0370
    2 THSS=THSTS(1)                                                     PROP0380
    4 IF(NPP.EQ.0.0) GO TO 3                                            PROP0390
      THSP=FGI(TL,NPP,TP,THP,IP)                                        PROP0400
      GO TO 1                                                           PROP0410
    3 THSP=THSTP(1)                                                     PROP0420
    1 STHSTS=STHS*THSS                                                  PROP0430
      STHSTP=STHP*THSP                                                  PROP0440
      FXS=THSS*CD-STHSTS*SD                                             PROP0450
      FXP=THSP*CD+STHSTP*SD                                             PROP0460
      FYS=-STHSTS*CD-THSS*SD                                            PROP0470
      FYP=STHSTP*CD+SD*THSP                                             PROP0480
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      FZS=-THSS*THETA*CD+STHSTS*SD*PHI                              PROP0490
      FZP=-THSP*THETA*CD-STHSTP*SD*PHI                              PROP0500
      FX=FXP+FXS                                                    PROP0510
      FY=FYP+FYS                                                    PROP0520
      FZ=FZP+FZS                                                    PROP0530
      FKP=-FZP*YP-FYP*ZP                                            PROP0540
      FKS=FZS*YP-FYS*ZP                                             PROP0550
      FK=FKS+FKP                                                    PROP0560
      FMS=FZS*(-XP)+FXS*ZP                                          PROP0570
      FMP=FZP*(-XP)+FXP*ZP                                          PROP0580
      FM=FMS+FMP                                                    PROP0590
      FNS=-FXS*YP-FYS*(-XP)                                         PROP0600
      FNP=FXP*YP-FYP*(-XP)                                          PROP0610
      FN=FNS+FNP                                                    PROP0620
      IF (IPROP.NE.ON) RETURN                                       PROP0630
      WRITE(6,123)                                                  PROP0640
  1   FX,FY,FZ,FK,FM,FN                                             PROP0650
123   FORMAT(/10X,22HPROP FX,FY,FZ,FK,FM,FN  /6E15.4)               PROP0660
      RETURN                                                        PROP0670
      END                                                           PROP0680


      SUBROUTINE RHS(VALUE)                                         RHS 0010
      INTEGER ON                                                    RHS 0020
      COMMON /AIR/ PINF,RHOINF,GAM                                  RHS 0030
      COMMON /BMCG/ IMX,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYRHS 0040
      COMMON /COLUMN/ IVERT,ILATRL                                  RHS 0050
      COMMON /CCNST/ PI,RAD,UO                                      RHS 0060
      COMMON /CNTRL/CONTH,CONTQ,CONTTH,CMULT,LOUVER,ACONTZ,ACONTW,ZEQUILRHS 0070
     1 ,THEQL,ACBASE                                                RHS 0080
      COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP, RHS 0090
     ATIP(25),TIS(25)                                               RHS 0100
      COMMON /FANMAP/QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,RHS 0110
     1 ,ENSFAN,ERPM,MRPM,SRFM,NPTSB,NPTSM,NPTSS                     RHS 0120
     2 ,PBFAN(25),PMFAN(25),PSFAN(25),DELB(25),NB,TMES(25),         RHS 0130
     3 DELTS(25),TNS                                                RHS 0140
      COMMON /FAERO/ FXAED,FYAED,FZAED,FKAED,FMAED,FNAED            RHS 0150
      COMMON /FORBS/ FXBS,FYBS,FZBS,FKBS,FMBS,QLBS                 RHS 0160
      COMMON /FORSS/ FXSS,FYSS,FZSS,FKSS,FMSS,FNSS,QLSS,FMS        RHS 0170
      COMMON /FPROP/ FXP,FYP,FZP,FKP,FMP,FNP                       RHS 0180
      COMMON /FRGUDE/ FN,FNCRIT                                    RHS 0190
      COMMON /FRUD/ FXRUD,FYRUD,FZRUD,FKRUD,FMRUD,FNRUD            RHS 0200
      COMMON /GEOM/ XBOW, WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM RHS 0210
      COMMON/GBOW/ XBOW,XCPO,ZCP                                   RHS 0220
     1,DELS(4,10)                                                  RHS 0230
      COMMON /GEOMBS/DETABX(11),DETABT(11),ARM1B(10),ARM2B(10)     RHS 0240
     1 ,DEFBS(10),TSKIB(10)                                        RHS 0250
      COMMON /GEOMSS/DETASX(11),DETADT(11),ARMIS(10),DFSS(10),TSKIS(10) RHS 0260
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1  ,ARM2S(10)     ITHRST                                                    RHS 0270
   COMMON /KSWTCH/ ITHRST                                                   RHS 0280
   COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,         RHS 0290
   -              AMI(20),XI(201),YI(201),ZI(201),XS,ZS,HRHO                RHS 0300
   COMMON /MATRIX/ A(6,6)                                                   RHS 0310
   COMMON /MSIDW/  DF(2,10),DSWAV(2,10),FXH(2),FYH(2),FZH(2),FMH(2),        RHS 0320
   1              FNH(2),VFX(2),VFY(2),VFZ(2),FXV                           RHS 0330
   COMMON /MWAVE/  FXW(2),FYW(2),FZW(2),FMW(2),FNW(2)                       RHS 0340
   COMMON /OPTION/ I3DUF,ISRGE,ITRIM,NVALID                                 RHS 0350
   COMMON /PLENUM/ XLBW,XBBW,ABW,BUBHGT                                     RHS 0360
   COMMON /PRIME/  STIME,FTIME,DELT,DELPNT,TPRINT                           RHS 0370
   COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,         RHS 0380
   -IRUD,IPROP,LAERGO,IRHS                                                  RHS 0390
   COMMON /PWAVE/  FNCON,PWVCON                                             RHS 0400
   COMMON /RUDDR/  NPR,DELRUD(25)                                           RHS 0410
   ARCLB,RTC,RUDANG,TIR(25)                                                 RHS 0420
   COMMON /SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSWRHS     RHS 0430
   1,VARTA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ ,AVBMSW,DELX,VTC             RHS 0440
   COMMON /SLOPE/WATSLP,XPWV,XLXPWV,XPWVXS                                  RHS 0450
   COMMON/SOFTBS/XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVG        RHS 0460
   1B(10)                                                                   RHS 0470
   COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS                  RHS 0480
   1,ELMAXS,YAVGS(10)                                                       RHS 0490
   COMMON /VALOLD/ YOLD(20)                                                 RHS 0500
   COMMON /VARBLE/ VAL(40)                                                  RHS 0510
   COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,               RHS 0520
   1             FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                        RHS 0530
   2             ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR                  RHS 0540
   EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),              RHS 0550
   1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),           RHS 0560
   2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),      RHS 0570
   3(VAL(2+),PB)                                                            RHS 0580
   EQUIVALENCE (VAL(18),FANPWR)                                             RHS 0590
   DATA NOTIN /0/                                                           RHS 0600
   DIMENSION ACCEL(3),ANGACL(3)                                            RHS 0610
   DIMENSION GF(6),VALUE(20)                                               RHS 0620
   DO 5 J=1,20                                                              RHS 0630
   VALUE(J)=0.0                                                             RHS 0640
C  CALCULATION OF BUBBLE WAVE MAKING DRAG                                   RHS 0650
   FN=U/FNCON                                                               RHS 0660
   CF=.37/(FN**1.565981)                                                    RHS 0670
   FXPWAV=-PWVCON*PBBAR*CF                                                  RHS 0680
   WATSLP=-FXPWAV/WEIGHT                                                    RHS 0690
   AB=ABW-(ABW-(XL*WIDTH))*(ZS+Z)/BUBHGT                                    RHS 0700
   VCL=VOLNUM-.5*(AB+ABW)*(Z+ZS)-DVOLW                                      RHS 0710
   1+.5*WATSLP*XL*AB                                                        RHS 0720
   PB=PINF*(BMASS/(VOL*RHOINF))**GAM                                        RHS 0730
   PBS=PB+DPBS                                                              RHS 0740
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      PSS=PB+DPSS                                                       RHS 0750
      PBAR=PB-PINF                                                      RHS 0760
      ABPB=PBAR*AB                                                      RHS 0770
      FLOW=SQRT(2.*ABS(PBAR)/RHOINF)*SIGN(1.,PBAR)                      RHS 0780
      QLSW=CFSW*ALSW*FLOW                                               RHS 0790
      CALL BOWSL                                                        RHS 0800
      CALL STNSL                                                        RHS 0810

      GF(1)=FXBS+FXSS+FXSW+FXRUD+FXP+FXWAV+FXAED         +FXPWAV        RHS 0820
      IF (ITHRST.NE.ITRIM) GO TO 11                                     RHS 0830
      THSTS(1)=THSTS(1)-GF(1)/2.                                        RHS 0840
      THSTP(1)=THSTP(1)-GF(1)/2.                                        RHS 0850
      THST=THSTS(1)+THSTP(1)                                            RHS 0860
      GF(1)=0.0                                                         RHS 0870
   11 CONTINUE                                                          RHS 0880
      GF(2)=-RU*AM+FYBS+FYSS+FYSW+FYRUD+FYP+FYWAV+FYAED                 RHS 0890
     +FZBS+FZSS+FZSW+FZRUD+FZP+FZWAV+FZAED                              RHS 0900
      GF(3)=WEIGHT-ABPB                                                 RHS 0910
      GF(4)=FKBS+FKSS+FKSW+FKRUD+FKP+FKWAV+FKAED +ABPB*PHI*(-Z)         RHS 0920
      XCP=XCPU                                                          RHS 0930
      GF(5)=FMBS+FMSS+FMSW+FMRUD+FMP+FMWAV+FMAED +ABPB*(XCP-THETA*Z )   RHS 0940
     +FXPWAV*(XCP-THETA*Z)                                             RHS 0950
      FMBUB=ABPB*(XCP-THETA*Z)                                          RHS 0960
      FMWAVZ=FXPWAV*ZS                                                  RHS 0970
      GF(6)=FNBS+FNSS+FNSW+FNRUD+FNP+FNWAV+FNAED                        RHS 0980
      IF (I3DOF .NE. 1) GO TO 100                                       RHS 0990
      GF(3)=0.0                                                         RHS 1000
      GF(5)=0.0                                                         RHS 1010
  100 CONTINUE                                                          RHS 1020
      DO 1 I=1,6                                                        RHS 1030
      VALUE(I)=0.0                                                      RHS 1040
      DO 1 J=1,6                                                        RHS 1050
      VALUE(I)=VALUE(I)+A(I,J)*GF(J)                                    RHS 1060
    1 CONTINUE                                                          RHS 1070
      VALUE(7)=P                                                        RHS 1080
      VALUE(8)=Q                                                        RHS 1090
      VALUE(9)=W                                                        RHS 1100
      IF (I3DOF .EQ. 1 ) GO TO 325                                      RHS 1110
C     BUBBLE PRESSURE EQUATION                                          RHS 1120
      QOUT=QLBS+QLSS+QLSW                                               RHS 1130
      CALL FAN                                                          RHS 1140
      QCNTRL=0.0                                                        RHS 1150
      VALUE(10)=RHOINF*(QIN-QOUT-QCNTRL)                                RHS 1160
      GO TO 236                                                         RHS 1170
  325 CONTINUE                                                          RHS 1180
      VALUE(10)=0.0                                                     RHS 1190
  236 CONTINUE                                                          RHS 1200
C     WRITE DATA FILE FOR MOMENT AND SHEAR CALCS., IF REQUIRED          RHS 1210
      IF ( IMT.NE.1 ) GO TO 111                                        RHS 1220
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      NBS = NSTA(3)-1                                                    RHS 1230
      NSS = NSTA(4)-1                                                    RHS 1240
      NSSL = NSS/2+1                                                     RHS 1250
      WRITE (IBMFIL)   (VAL(I),I=1,24),ZBAR,PHIBAR,THEBAR,               RHS 1260
     1 FXW,FYW,FZW,FKW,FMW,FNW, (VALUE(I),I=1,10),                       RHS 1270
     2 DF,DSWAV,FXH,FYH,FZH,FMH, FNH,VFY,VFZ,FXV ,                       RHS 1280
     3 FXRUD,FYRUD,FXP,FYP,FZP, FZSS,FKSS,FMSS,FXBS,FZBS,                RHS 1290
     4 FXAED,FYAED,FZAED,FMAED, FNAED,FXSS,FKBS,FMBS                     RHS 1300
     X ,FNBS,FNSS ,(TSKIS(I),DFSS(I),I=NSSL,NSS)                         RHS 1310
     Y ,(TSKIB(I),DFBS(I),ARMIB(I),ARM2B(I),I=1,NBS)                     RHS 1320
  111 CONTINUE                                                          RHS 1330
C     CONSTANT LONGITUDINAL VELOCITY ( U )                              RHS 1340
      IF (ISRGE .EQ.1) VALUE(1)=0.0                                     RHS 1350
      IF (ON.NE.1) RETURN                                               RHS 1360
      DO 2 I=1,3                                                        RHS 1370
      ACCEL(I)=VALUE(I)/G                                               RHS 1380
      ANGACL(I)=VALUE(I+3)*RAD                                          RHS 1390
    2 CONTINUE                                                          RHS 1400
      BOWACC=ACCEL(3)-XBOW*VALUE(5)/G                                   RHS 1410
      STRACC=ACCEL(3)+XS*VALUE(5)/G                                     RHS 1420
      IF(IVERT.NE.ON) GO TO 10                                          RHS 1430
      ZD=Z+ZS                                                           RHS 1440
      THETAR=THETA*RAD                                                  RHS 1450
   10 IF(ILATRL.NE.ON) GO TO 15                                         RHS 1460
      DEPSI=PSI*RAD                                                     RHS 1470
      RDEG=R*RAD                                                        RHS 1480
      BETAS=-V/U*RAD                                                    RHS 1490
      ACCLAT=(VALUE(2)+U*R)/G                                           RHS 1500
      DPHI=PHI*RAD                                                      RHS 1510
      DRFT=12.0*ZD                                                      RHS 1520
      VEL=0.59249*U                                                     RHS 1530
      CCLRS=KUDANG*RAD                                                  RHS 1540
      IF(P.EQ.0.0) GO TO 115                                            RHS 1550
      TRADUS=U/R                                                        RHS 1560
      GO TO 20                                                          RHS 1570
  115 TRADUS=1.E3                                                       RHS 1580
   20 WRITE(1)TIME,VAL(16),DRFT,THETAR,PBAR,BOWACC,ACCEL(3),FANPWR,DPHI,RHS 1590
     1DEPSI,CCLAT,VEL,TRADUS,RDEG,X,Y,GIN,QOUT,GF(1),FXPWAV,GF(2),GF(3) RHS 1600
     2,GF(4),GF(5),GF(6),DELRS                                          RHS 1610
   15 IF(IRHS .NE. ON) RETURN                                           RHS 1620
      WRITE(6,77) FMBS,FMSS,FMSW,FMRUD,FMP,FMWAV,FMAED,FMBUB,FWAVZ      RHS 1630
   77 FORMAT('0',6X,5HFMBS=,E16.6,2X,5HFMSS=,E16.6,2X,5HFMSW=,          RHS 1640
     AE16.6,/,'0',6X,6HFMRUD=,E16.6,2X,4HFMP=,E16.6,2X,6HFMWAV=,E16.6,  RHS 1650
     B/,'0',6X,6HFMAED=,E16.6,2X,6HFMBUB=,E16.6,2X,6HFWAVZ=,E16.6)      RHS 1660
      WRITE(6,401)FXPWAV                                                RHS 1670
  401 FORMAT('0',6X,7HFXPWAV=,E16.6)                                    RHS 1680
      WRITE(6,200) PBAR,FANPWR,QIN,QLBS,QLSW,QLSS                       RHS 1690
      WRITE(6,215) AB,VOL                                               RHS 1700
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         WRITE(6,150) GF,ACCEL,ANGACL                              RHS 1710
         WRITE(6,175)BOWACC,STNACC                                 RHS 1720
 200 FORMAT(//10X,3HRHS                                            RHS 1750
     120H GAGE PRESS. (PSF) = F7.2,5X,21HFAN POWER REQD (HP) = F8.2, RHS 1760
     225X,27HFAN FLOW RATE (CU FT/SEC) = F9.2, //11H BOW SEAL = F9.2, RHS 1770
     3//31H LEAKAGE FLOW RATES (CU FT/SEC) //11H BOW SEAL = F9.2, RHS 1780
     411H SIDEWALL = F9.2,13H STERN SEAL = F9.2)                   RHS 1790
 215 FORMAT(//13H PLENUM AREA= F9.2,10X,14HPLENUM VOLUME= F10.2)   RHS 1800
 213 FORMAT((//12H VALUE ARRAY 2(/10E13.4)/10H VAL ARRAY 4(/10E13.4)) RHS 1810
 150 FORMAT(//10X,24HTOTAL FORCES AND MOMENTS 6E12.4/10X,24HACCELERATIONRHS 1820
     -S G/DEG/SEC2 6E12.4)                                        RHS 1830
 175 FORMAT(//10X,16HBOW ACCEL. (G) = E12.4,21H   STERN ACCEL. (G) = E12RHS 1840
     -.4)                                                          RHS 1850
         RETURN                                                    RHS 1860
         END                                                       RHS 1870
                                                                   RHS 1880

      SUBROUTINE RUDDER                                            RUD 0020
      INTEGER ON                                                   RUD 0030
      COMMON /CONST/ PI,RAD,UO                                     RUD 0040
      COMMON /FRUD/ FX,FY,FZ,FK,FM,FN                              RUD 0050
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS, RUD 0060
     AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO                  RUD 0070
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,ISTNSL,IWAVES,    RUD 0080
     -IRUD,IPROP,IAEROD,IRHS                                       RUD 0090
      COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,KAREA,RASPR, RUD 0100
     ARCLB,RTC,RUDANG,TIR(25)                                      RUD 0110
      COMMON /VARBLE/ VAL(40)                                      RUD 0120
                                                                   RUD 0130
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),  RUD 0140
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA), RUD 0150
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),RUD 0160
     3(VAL(24),P3)                                                 RUD 0170
      EQUIVALENCE (CELRUD(1),RUD(1)),(TIR(1),TR(1))                RUD 0180
      DIMENSION RUD(1),TR(1)                                       RUD 0190
      EQUIVALENCE (VAL(18),FANPWR)                                 RUD 0200
      DATA ENU /1.28E-5/                                           RUD 0210
                                                                   RUD 0220
C        CALCULATE PROGRAMMED RUDDER DEFLECTION                    RUD 0230
      TL=TIME                                                      RUD 0240
      IF(NPR.EQ.0.0) GO TO 5                                       RUD 0250
      GO TO 6                                                      RUD 0260
    5 RUDANG=DELRUD(1)                                             RUD 0270
      RUDANG=RUDANG/RAD                                            RUD 0280
      GO TO 7                                                      RUD 0290
    6 RUDANG=FG1(TL,NPR,TR,RUD,IR)                                 RUD 0300
      RUDANG=RUDANG/RAD                                            RUD 0310
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C         SIDE FORCE ON RUDDER                                          RUD 0320
7         DSR=Z+ZS-XR*THETA                                            RUD 0330
          ENDFAC=(1.+DSR/(DSR+RSPAN))                                  RUD 0340
          VH=V+XR*R-ZR*P                                               RUD 0350
          QQ=HRHO*U*U*RAREA                                            RUD 0360
          EFFANG=RUDANG-ENDFAC*VH/U                                    RUD 0370
          FY=2.*QQ*ENDFAC*RCLB*EFFANG                                  RUD 0380
C         DRAG FORCE UN RUDDER                                         RUD 0400
          REY=U*(RAREA/RSPAN)/ENU                                      RUD 0410
          CFK=.472/(ALOG10(REY)-.407)**2.64                            RUD 0420
          PI8=PI/8.                                                    RUD 0430
          CD=2.*CFK+ PI8*RTC*RTC*(1.+G*RSPAN/(U*U))+RCLB*EFFANG*EFFANG  RUD 0440
          FX=-2.*CD*RAREA*HRHO*U*U                                     RUD 0450
          FZ=0.                                                        RUD 0470
          FK=-ZR*FY                                                    RUD 0480
          FM=FX*ZR                                                     RUD 0490
          FN=XR*FY                                                     RUD 0500
          IF(IRUD.NE.ON) RETURN                                        RUD 0510
                          WRITE(6,123)                                 RUD 0520
123 1     FX,FY,FZ,FK,FM,FN                                            RUD 0530
          FORMAT(/10X,24HRUDDER  FX,FY,FZ,FK,FM,FN /6E15.4)            RUD 0540
          RETURN                                                       RUD 0550
          END                                                          RUD 0560

          SUBROUTINE SAM                                               SAM 0020
          WRITE (6,10)                                                 SAM 0030
10        FORMAT (1H1,'YOU HAVE CALLED A DUMMY SAM SUBROUTINE.'/        SAM 0040
     1    10X,'CHANGE TO BHISES TO USE THE SAM SUBROUTINE.')           SAM 0050
          RETURN                                                       SAM 0060
          END                                                          SAM 0070

C                                                                      T1  0010
          FUNCTION T1(X)                                               T1  0020
          IF(ABS(X)-.1) 10,10,20                                       T1  0030
10        T1=X*(1.-X*X/10.0)/3.                                        T1  0050
          RETURN                                                       T1  0060
20        T1=(SIN(X)-X*COS(X))/(X*X)                                   T1  0070
          RETURN                                                       T1  0080
          END

C                                                                      T2  0010
          FUNCTION T2(X)                                               T2  0020
          IF(ABS(X)-.1) 10,10,20                                       T2  0030
10        T2=1.-X*X/6.                                                 T2  0040
          RETURN                                                       T2  0050
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      T2=SIN(X)/X                                                       T2  0060
      RETURN                                                            T2  0070
      END                                                               T2  0080
      SUBROUTINE SIDEWL                                                 SDWL0010
      INTEGER UN                                                        SDWL0020
      COMMON /AIR/ PINF,RHOINF,GAM                                      SDWL0030
      COMMON /BMCO/ IMM,INNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IY SDWL0040
      COMMON /CONST/ PI,RAD,UO                                          SDWL0050
      COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNCM        SDWL0060
     1,DELS(4,10),XCP,ZCP                                               SDWL0070
      COMMON /GEOMSW/ XAVG(10),DS                                       SDWL0080
      COMMON /KSWTCH/ ITHRST                                            SDWL0090
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  SDWL0100
     1AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO                       SDWL0110
      COMMON /MSIDW/ DF(2,10),DSWAV(2,10),FXH(2),FYH(2),FZH(2),FMH(2),  SDWL0120
     1FNH(2),VFY(2),VFZ(2),FXV                                          SDWL0130
      COMMON /PLENUM/XLRW,XBBW,ABW,BUBHGT                               SDWL0140
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                     SDWL0150
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  SDWL0160
     -IRUD,IPROP,IAERO,IRHS                                             SDWL0170
      COMMON /SIDE/FX  ,FY  ,FZ  ,FK  ,FM  ,FN  ,ALSW,YSW,XLSW,CFSW,CDSWSDWL0180
     1,VAREA ,VCHORD,VSPAN,VANGLE,YCOS,VX,VY,VZ ,AVBMSW,DELX,VTC        SDWL0190
      COMMON /SLOPE/WATSLP,XPWV,XLXPWV,XPWVXS                           SDWL0200
      COMMON /VARBLE/ VAL(40)                                           SDWL0210
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,        SDWL0220
     1FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                               SDWL0230
     2,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET                              SDWL0240
      COMMON /WAVTAB/ NAL,SAL,NDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,          SDWL0250
     1AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),                  SDWL0260
     2AC5(20,5,7),AC6(20,5,7),AC7(20,5,7),                             SDWL0270
     3,AC0(20,5,7),AC0O(20,5,7),AS1(20,5,7),AS4(20,5,7),                SDWL0280
     4AS5(20,5,7),AS2(20,5,7),AS3(20,5,7),                              SDWL0290
     5,AS0(20,5,7),AS6(20,5,7),AS7(20,5,7),AS8(20,5,7)                  SDWL0300
     6,AS0O(20,5,7)                                                     SDWL0310
     7,BB(36),XREF,KX                                                   SDWL0320
      EQUIVALENCE (VAL(2),U),(VAL(3),V),(VAL(4),W),                     SDWL0330
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     SDWL0340
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),SDWL0350
     3(VAL(24),PB)                                                      SDWL0360
      DIMENSION GAP(2,11),DSW(2,11)                                     SDWL0370
      DATA ENU /1.28E-5/                                                SDWL0380
C     WETTED DRAFT CALCULATION                                          SDWL0390
      PBHEAD=PBAR/(RHO*G)                                               SDWL0400
      GAP OR                                                            SDWL0410
      DO 10 J=1,2                                                       SDWL0420
      N=NSTA(J)                                                         SDWL0430
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      DO 10 K=1,N
      DD=ZS+Z+YY(J,K)*PHI-XX(1,K)*THETA+ETA(J,K)          SDWL0440
      DDIN=DD-WATSLP*(XPW+XS-XX(J,K))                       SDWL0450
      IF(DDIN.LT.BUBHGT) GO TO 101                          SDWL0460
      IF( VAL(1)-TOLD .LT. DELPNT )  GO TO 101              SDWL0470
      TOLD = VAL(1)                                         SDWL0480
      WRITE (6,100) XX(J,K),VAL(1),DD                       SDWL0490
100   FORMAT(/10X,43HWATER CONTACT WITH TOP OF BUBBLE CHAMBER AT F7.2,  SDWL0500
     -14H FT.     TIME = F7.2,19H SEC.     IMMERSION= F7.2,4H FT. )     SDWL0510
101   CONTINUE                                             SDWL0520
      DSW(J,K)=(SIGN(1.,DD)+1.)*DD/2.                       SDWL0530
      IF (DDIN) 6,3,8                                       SDWL0540
6     IF (DSW(J,K)-PBHEAD) 7,8,8                            SDWL0550
7     GAP(J,K)=-DDIN*(1.-(DSW(J,K))/PBHEAD)                 SDWL0560
      GO TO 10                                              SDWL0570
8     GAP(J,K)=0.0                                          SDWL0580
10    CONTINUE                                              SDWL0590
C     LEAKAGE AREA                                          SDWL0600
      ALSW=0.0                                              SDWL0610
      DO 20 J=1,2                                           SDWL0620
      N=NSTA(J)-1                                           SDWL0630
      DO 20 I=1,N                                           SDWL0640
      ALSW=ALSW+(GAP(J,I)+GAP(J,I+1))*DELX/2.               SDWL0650
20    CONTINUE                                              SDWL0660
C                                                           SDWL0670
C     CROSS-FLOW DRAG ON SIDEWALLS                          SDWL0680
      FYD=0.0                                               SDWL0690
      FKD=0.0                                               SDWL0700
      FND=0.0                                               SDWL0710
      DO 15 I=1,2                                           SDWL0720
      N=NSTA(I)-1                                           SDWL0730
      DO 15 J=1,N                                           SDWL0740
      DSWAV(I,J)=(DSW(I,J)+DSW(I,J+1))/2.                   SDWL0750
      VREL= V+XAVG(J)*R-(ZS-DSWAV(I,J)/2.)*P                SDWL0760
      DF(I,J)=- HRHO*CDSW*VREL *ABS(VREL) *DSWAV(I,J)       SDWL0770
      FYD=FYD+DF(I,J)*XAVG(J)                               *DELX   *DSWAV(I,J)   SDWL0780
      FKD=FKD+DF(I,J)*(ZS-DSWAV(I,J)/2.)*DF(I,J)            SDWL0790
C     SET UP STERM LIMIT OF FORCE DETERMINATION             SDWL0800
      XSS = -XS                                             SDWL0810
      GO TO 16                                              SDWL0820
      ENTRY SIDWLM                                          SDWL0830
      XSS = XMI(IX)                                         SDWL0840
16    IP=1.+(THETA*RAD-STH)/DTH                             SDWL0850
      IP=MAXO(MINO(IP,NTH),1)                               SDWL0860
      IP1=MINO(IP+1,NTH)                                    SDWL0870
      DTHETA=(IP-1)*DTH+STH                                 SDWL0880
      DIP=(THETA*RAD-DTHETA)/DTH                            SDWL0890
                                                            SDWL0900
                                                            SDWL0910
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C     CALC REYNOLDS NO. AND DRAG COEFF.                              SDWL0920
      REY=U*XLSW/ENU                                                 SDWL0930
      CDT=.427/(ALOG10(REY)-.407)**2.64                              SDWL0940
C                                                                    SDWL0950
C     SIDEWALL FORCES, P/S                                           SDWL0960
      DO 40 J=1,2                                                    SDWL0970
      WAREA=0.0                                                      SDWL0980
      N=NSTA(J)-1                                                    SDWL0990
      NI=(XSS+XS)*N/XLSW+1.5                                         SDWL1000
      DO 21 I=NI,N                                                   SDWL1010
      ZOR1=1.                                                        SDWL1020
      IF(DSWAV(J,I).EQ..0.0) ZOR1=0.0                                SDWL1030
      WAREA=WAREA+DELX*(2.*DSWAV(J,I)+ZOR1*AVBMSW)                   SDWL1040
      FXH(J)=- HRHO*CDT*WAREA*U*U                                    SDWL1050
      PM1=2*J-3                                                      SDWL1060
21    YLSW=PM1*YSW   +ZS+YLSW*PHI                                    SDWL1070
      DSS=DS-XSS*THETA                                               SDWL1080
      ZOR1=(SIGN(1.,DSS)+1.)/2.                                      SDWL1090
      DSS=DSS*ZOR1                                                   SDWL1100
      IDSS=1.5+(DSS-SBB)/DBB                                         SDWL1110
      IDSS=MINO(NBB,IDSS)                                            SDWL1120
      BS=SBB(IDSS)                                                   SDWL1130
      ZOR1=(SIGN(1.,DSS)+1.)/2.                                      SDWL1140
      DSS=DSS*ZOR1                                                   SDWL1150
      A33S=(RHO*PI*BS**2)/8.                                         SDWL1160
      A22S=(RHO*.4*PI*DSS**2)/2.                                     SDWL1170
      DSP=DS-(XREF-XS)*THETA                                         SDWL1180
      IC=1.+X+(DSR*12.-SDS)/DDS                                      SDWL1190
      IC=MAX0(MIN0(IC,NDS),1)                                        SDWL1200
      DDSR=(IC-1)*DDS+SDS                                            SDWL1210
      IDI=MIN0(ID+1,NDS)                                             SDWL1220
      DID1=(DSR*12.-DDSR)/DDS                                        SDWL1230
      BCO0=ACO0(1,ID,IP)                                             SDWL1240
      BCO0=ACO0(1,ID,IP)                                             SDWL1250
      BC2=AC2(1,ID,IP)                                               SDWL1260
      BC5=AC5(1,ID,IP)                                               SDWL1270
      BC6=AC6(1,ID,IP)                                               SDWL1280
      BCO =BCO +DID*(ACO (1,ID1,IP)-ACO (1,ID,IP)-BCO )+DIP*(ACO (1,ID,IP1)-BCO )   SDWL1290
     1 BCO0=BCO0+DID*(ACO0(1,ID1,IP)-ACO0(1,ID,IP)-BCO0)+DIP*(ACO0(1,ID,IP1)+BCO0)  SDWL1300
     1 +DID*(ACO0(1,ID1,IP1)-ACO0(1,ID1,IP)+BCO0)                    SDWL1310
      BC2 =BC2 +DID*(AC2 (1,ID1,IP)-AC2 (1,ID,IP)-BC2 )+DIP*(AC2 (1,ID,IP1)-BC2 )    SDWL1320
     1 +DID*(AC2 (1,ID1,IP1)-AC2 (1,ID1,IP)+BC2 )                    SDWL1330
      BC5 =BC5 +DID*(AC5 (1,ID1,IP)-AC5 (1,ID,IP)-BC5 )+DIP*(AC5 (1,ID,IP1)-BC5 )    SDWL1340
     1 +DID*(AC5 (1,ID1,IP1)-AC5 (1,ID1,IP)+BC5 )                    SDWL1350
      BC6 =BC6 +DID*(AC6 (1,ID1,IP)-AC6 (1,ID,IP)-BC6 )+DIP*(AC6 (1,ID,IP1)-BC6 )    SDWL1360
     1 +DID*(AC6 (1,ID1,IP1)-AC6 (1,ID1,IP)+BC6 )                    SDWL1370
                                                                     SDWL1380
                                                                     SDWL1390
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C     SHIFT MOMENT CENTER FROM XREF TO C.G.                        SDWL1400
      BCOO = BCOO-(XS-XREF)*BCO                                    SDWL1410
      BC6 = BC6 -(XS-XREF)*BC5                                     SOWL1420
C     HYDROSTATIC AND HYDRODYNAMIC FORCES                          SDWL1430
      FZH(J) =-G*BCO-U*U*A33S*THETA-U*A33S*W+Q*U*(-BC2+A33S*XSS)   SDWL1440
     1  -U*A33S*P)                                                 SDWL1450
      +YLSW                                                        SDWL1460
      FMH(J) =-U*XSS*XSS*A33S*Q+G*BCOO+U*(A33S*XSS+BC2)*(W+U*THETA SOWL1470
     +YLSW*P)                                                      SOWL1480
      FYH(J) =-A22S*U*(V+XSS*R  -ZS*P)                             SOWL1490
      FNH(J) = FYH(J)*XSS-U*((V-ZS*P)*BC5+R*BC6)                   SDWL1500
      IF (IMT.EQ.2) GO TO 40                                       SDWL1510
   39 CONTINUE                                                     SDWL1520
   40 CONTINUE                                                     SOWL1530
      IF (IMT.EQ.2)  RETURN                                        SDWL1540
C     TOTAL SIDEWALL FORCES AMD MOMENTS                            SDWL1550
      FX=FXH(1)+FXH(2)                                             SOWL1560
      FY=FYH(1)+FYH(2)                                             SOWL1570
      FZ=FZH(1)+FZH(2)                                             SDWL1580
      FK=(FZH(2)-FZH(1))*YSW       +FKD  -FY*ZS                    SDWL1590
      FY=FY+FYD                                                    SOWL1600
      FM=FMH(1)+FMH(2)+ZS*FX                                       SOWL1610
      FN= FND +FNH(1)+FNH(2) +(FXH(1)-FXH(2))*YSW                  SOWL1620
      IF (ISIOWL.NE.ON) RETURN                                     SDWL1630
      DO 41 I=1,2                                                  SOWL1640
      DO 41 J=1,11                                                 SDWL1650
   41 GAP(I,J)=12.-2.0*GAP(I,J)                                    SOWL1660
      OSW(I,J)=12.-2.0*DSW(I,J)                                    SOWL1670
      WRITE( 6,123) ((GAP(I,J),J=1,11),I=1,2),((DSW(I,J),J=1,11),I=1,2), SOWL1680
  123 FORMAT(/10X,8HSIOEWALL /25H GAP (FT.) (STERN TO BOW) /14H PORT SIDSOWL1690
     1EWALL /11F10.5/14H STBD SIOEWALL /11F10.5/37H IMMERSION DEPTH (FT. SOWL1700
     2) 11F10.5/10X,25HSIOEWALL /14H PORT SIOEWALL /11F10.5/14H STBD SIDEWALL / SDWL1710
     3 11F10.5/10X,25HSIOEWALL FX,FY,FZ,FK,FM,FN /6E15.4)          SDWL1720
      RETURN                                                       SDWL1730
      END                                                          SOWL1740

      SUBROUTINE STNSL                                             SSL 0010
      INTEGER CN                                                   SSL 0020
      COMMON /AIR/ PINF,RHOINF,GAM                                 SSL 0030
      COMMON /CONST/ PI,RAD,UO                                     SSL 0040
      COMMON / FORSS/ FX,FY,FZ,FK,FM,FN,QL,FMS                     SSL 0050
      COMMON /GEUM/  WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM  SSL 0060
     1:0ELS(4:10):XCP:ZCP                                          SSL 0070
      COMMON /GEOMSS/DETADX(11),OETADT(11),ARMIS(10),DFSS(10),TSKIS(10) SSL 0080
     1 ,ARM2S(10)                                                  SSL 0090
      COMMON /KSWTCH/ ITHRST                                       SSL 0100
      COMMON /LEAKER/ ALEAK,CFSS                                   SSL 0110
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      COMMON /MASSES/  AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,         SSL 0120
     -                 AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO             SSL 0130
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,         SSL 0140
     -IRUD,IPROP,IAEROD,IRHS                                                   SSL 0150
      COMMON /SLOPE/WATSLP,XPWV,XLXPWV,XPWVXS                                  SSL 0160
      COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS                  SSL 0170
     1 ,ELMAXS,YAVGS(10)                                                       SSL 0180
      COMMON /STSLR/ CPHI,CPHID                                               SSL 0190
      COMMON / VALOLD / YOLD(20)                                              SSL 0200
      COMMON /VARBLE/ VAL(40)                                                 SSL 0210
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,              SSL 0220
     1          FXWAV,FYWAV,FZWAV,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR        SSL 0230
     2          ZBAR,PHIBAR,FKWAV,FMWAV,FNWAV                                 SSL 0240
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),           SSL 0250
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(2),X),(VAL(22),Y),(VAL(23),PSI),       SSL 0260
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),             SSL 0270
     3(VAL(24),PB)                                                            SSL 0280
      DIMENSION GAP(11),ELSKI(11)                                             SSL 0290
      DATA ENJ,UWSKI,CLSKI / 1.28E-5,  0.0,  1.5708/                          SSL 0300
      DO 5 J=1,11                                                             SSL 0310
      GAP(J)=0.0                                                              SSL 0320
      ELSKI(J)=0.0                                                            SSL 0330
    5 CONTINUE                                                                SSL 0340
      ALSS=0.0                                                                SSL 0350
      FX=0.00                                                                 SSL 0360
      FZ=0.00                                                                 SSL 0370
      FK=0.00                                                                 SSL 0380
      FM=0.00                                                                 SSL 0390
      FN=0.00                                                                 SSL 0400
      DELP=PSS-PB                                                             SSL 0410
      IF (DELP.LT.0.0) DELP=0.0                                              SSL 0420
      PBAR=PB-PINF                                                            SSL 0430
C     CALCULATE ELSKI HERE.                                                   SSL 0440
      SINDIF=SINTH-COSTH*THETA                                                SSL 0450
      COSDIF=COSTH+SINTH*THETA                                                SSL 0460
      XI=XSS+ZSS*THETA-XLF*SINDIF                                             SSL 0470
      ZI=(-Z-ZSS+XSS*THETA-XLF*COSDIF)                                        SSL 0480
C     CALCULATE GAP HERE.                                                     SSL 0490
      N=NSTA(4)                                                               SSL 0500
      DO 10 K=1,N                                                             SSL 0510
      ELSKI(K)=(ETA(4,K)-DETADX(K)*(XX(4,K)-X1)-Z1)+YY(4,K)*PHI              SSL 0520
     1-XPWV*WATSLP                                                            SSL 0530
      GAP(K)=-ELSKI(K)                                                        SSL 0540
      IF (GAP(K) .LT. 0.0) GAP(K)=0.0                                        SSL 0550
   10 CONTINUE                                                                SSL 0560
      N=NSTA(4)-1                                                             SSL 0570
      DO 20 J=1,N                                                             SSL 0580
      ELSKIA=(ELSKI(J+1)+ELSKI(J))/2.                                         SSL 0590
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       IF (ELSKIA.LE.0.0)GO TO 15                                     SSL 0600
       IF (ELSKIA.GT.ELMAXS) ELSKIA=ELMAXS                            SSL 0610
       ARMIS(J)=XX(4,J)+ELSKIA/2.                                     SSL 0620
       ARM2S(J)=ZS-ELSKIA                                             SSL 0630
       DFSS(J)=-DELP*ELSKIA*DELYSS                                    SSL 0640
       ARG=.5*RHO*U*ELSKIA*DELYSS                                     SSL 0650
       RESKI =U*ELSKIA/ENU                                            SSL 0660
       CDTSKI=.427/(ALOG10(RESKI)-.407)**2.64                        SSL 0670
       TSKIS(J) = - ARG*CDTSKI                                        SSL 0680
       GO TO 18                                                       SSL 0690
   15  DFSS(J)  = 0.0                                                 SSL 0700
       TSKIS(J) = 0.0                                                 SSL 0710
   18  CONTINUE                                                       SSL 0720
       FX=FX+TSKIS(J)                                                 SSL 0730
       FZ=FZ+DFSS(J)                                                  SSL 0740
       FK=FK+DFSS(J)*YAVGS(J)                                         SSL 0750
       FM=FM-DFSS(J)*ARMIS(J)+TSKIS(J)*ARM2S(J)                       SSL 0760
       FN=FN-TSKIS(J)*YAVGS(J)                                        SSL 0770
       ALSS=ALSS+(GAP(J)+GAP(J+1))*DELYSS/2.0                         SSL 0780
   20  CONTINUE                                                       SSL 0790
       ALSS=ALSS+ALEAK                                                SSL 0800
       QL=CFSS*ALSS*SQRT(2.*ABS(PBAR)/RHOINF)*SIGN(1.,PBAR)           SSL 0810
       IF (HSTNSL.NE.ON) RETURN                                       SSL 0820
       WRITE(6,100) GAP,ELSKI,FX,FY,FZ,FK,FM,FN   PORT TO STBD.       SSL 0830
  100  FORMAT(//12H  STERN SEAL /26H  GAP (FT.) PORT TO STBD. /11E11.3/10X,23HSTNSL  FX,FY,FZ,FKSSL 0840
      1/20H  ELSKI (FT.) PORT TO STBD. /11E11.3                       SSL 0850
      2,FK,FN /6E15.4)                                                SSL 0860
       RETURN                                                         SSL 0870
       END                                                            SSL 0880

       SUBROUTINE WAVES(TIME)                                        WAVS0010
       INTEGER ON                                                    WAVS0020
       COMMON /BXCO / INM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYWAVS0030
      1      /CONST/ PI,RAD,UO                                       WAVS0040
       COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM     WAVS0050
      1,DELS(4,10),XCPO,ZCP                                          WAVS0060
       COMMON /GEOMBS/DETABX(11),DETABT(11),ARM1B(10),ARM2B(10)      WAVS0070
      1 ,DFBS(10),TSKIB(10)                                          WAVS0080
       COMMON /GEOMSS/DETADX(11),DETADT(11),ARM1S(10),DFSS(10),TSKIS(10)WAVS0090
      1 ,ARM2S(10)                                                   WAVS0100
       COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,WAVS0110
      1      AMI(20),XI(20),YI(20),ZI(20),XS,ZS,HRHO                 WAVS0120
       COMMON /MWAVE/ FXW(2),FYW(2),FZW(2),FKW(2),FMW(2),FNW(2)      WAVS0130
       COMMON /PLENUM/XLBW,XBBW,ABW,BUBHGT                           WAVS0140
       COMMON /PKTINT/ON,IACCEL,IVEL,IITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,WAVS0150
      -IROD,IPFOP,IAEROD,IRHS                                        WAVS0160
       COMMON /RISER/ AMPTC                                          WAVS0170
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      COMMON /SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSW WAVS0180
     1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ  ,AVBMSW,DELX,VTC        WAVS0190
      COMMON /VARBLE/ VAL(40)                                            WAVS0200
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,         WAVS0210
     1 FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                               WAVS0220
      COMMON /WAVTAB/ NAL,OAL,SAL,NDS,DOS,SDS,NTH,DTH,STH,NEB,DBB,SBB,   WAVS0230
     2 ,ZBAK,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR                        WAVS0240
     1 AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),                  WAVS0250
     2 AC5(20,5,7),AC6(20,5,7),AC7(20,5,7),                             WAVS0260
     3 ,ACO(20,5,7),AC00(20,5,7),AS3(20,5,7),AS4(20,5,7),               WAVS0270
     4 AS1(20,5,7),AS2(20,5,7),                                         WAVS0280
     5 AS5(20,5,7),AS6(20,5,7),AS7(20,5,7),AS8(20,5,7)                  WAVS0290
     6 ,ASO(20,5,7),AS00(20,5,7)                                        WAVS0300
     7 ,BB(36),XREF,RX                                                  WAVS0310
      DIMENSION WC0(2),WC00(2),WC1(2),WC2(2),WC3(2),WC4(2),WC5(2),WC6(2)WAVS0320
     1 ,WC7(2),WC8(2)                                                   WAVS0330
      DIMENSION WS0(2),WS00(2),WS1(2),WS2(2),WS3(2),WS4(2),WS5(2),WS6(2)WAVS0340
     1 ,WS7(2),WS8(2)                                                   WAVS0350
      EQUIVALENCE       (VAL(1),P),(VAL(2),U),(VAL(3),V),(VAL(4),W),    WAVS0360
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     WAVS0370
     2(VAL(10),Z),(VAL(11),RMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),WAVS0380
     3(VAL(24),PB)                                                      WAVS0390
      EQUIVALENCE (VAL(16),ETACG)                                       WAVS0400
      IF (NWAVE.EQ.0) RETURN                                            WAVS0410
      XCP=XCPO                                                          WAVS0420
      GAMMA=BETA-PSI                                                    WAVS0430
      SIGAM=SIN(GAMMA)                                                  WAVS0440
      CUGAM=COS(GAMMA)                                                  WAVS0450
      FO= -X*COSBET -Y*SINBET                                           WAVS0460
      DVOLW=0.0                                                         WAVS0470
      ETACG=0.0                                                         WAVS0480
      N=NSTA(3)                                                         WAVS0490
      DO 1 J=1,N                                                        WAVS0500
    1 DETA6X(J)=0.0                                                     WAVS0510
      CONTINUE                                                          WAVS0520
      N=NSTA(4)                                                         WAVS0530
      DO 2 J=1,N                                                        WAVS0540
    2 DETADX(J)=0.0                                                     WAVS0550
      CONTINUE                                                          WAVS0560
      DO 10 J=1,4                                                       WAVS0570
      N=NSTA(J)                                                         WAVS0580
      DO 10 K=1,N                                                       WAVS0590
      ETA(J,K)=0.0                                                      WAVS0600
   10 DO 15 J=1,2                                                       WAVS0610
      FXW(J) = 0.0                                                      WAVS0620
      FYW(J) = 0.0                                                      WAVS0630
      FZW(J) = 0.0                                                      WAVS0640
      FKW(J) = 0.0                                                      WAVS0650
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      FMW(J) = 0.0
      FNW(J) = 0.0                                                      WAVS0660
15    CONTINUE                                                         WAVS0670
      XSS = -XS                                                        WAVS0680
      IF (IMT .EQ. 2) XSS = XMI(IX)                                    WAVS0690
      IP = 1 +(THEBAR*RAD-STH)/DTH                                     WAVS0700
      IP=MAXO(MINO(IP,NTH),1)                                          WAVS0710
      IP1=MINO(IP+1,NTH)                                               WAVS0720
      DTHETA=(IP-1)*DTH+STH                                            WAVS0730
      DIP= (THETA*RAD-DTHETA)/DTH                                      WAVS0740
C     TIME RISE FACTOR FOR WAVE AMPLITUDE                              WAVS0750
      AMPFAC=1.-EXP(-TIME/AMPTC)                                       WAVS0760
      DO 100 I=1,NWAVE                                                 WAVS0770
      OM1=OMEGA(I)                                                     WAVS0780
      OM2=OM1*OM1                                                      WAVS0790
      XWK=OM2/G                                                        WAVS0800
      AA=AN(I)*AMPFAC                                                  WAVS0810
      FT=OM1*TIME+XWK*CUGAM                                            WAVS0820
      AL=XWK*CUGAM                                                     WAVS0830
      IAA= 1+(ABS(AL)-SAL)/DAL                                         WAVS0840
      IAA=MAXO(MINO(IAA,NAL),1)                                        WAVS0850
      IAA1=MINO(IAA+1,NAL)                                             WAVS0860
      DAA= (IAA-1)*DAL+SAL                                             WAVS0870
      DIA= (ABS(AL)-DAA)/DAL                                           WAVS0880
      SALP=SIGN(1.,AL)                                                 WAVS0890
C     WAVE FORCES AND MOMENTS ON THE SIDEWALLS                         WAVS0900
      DO 40 J=1,2                                                      WAVS0910
      YLSW=(-J+3)*YSW                                                  WAVS0920
      WE=FT+XWK*SIGAM*YLSW                                             WAVS0930
      ST=SIN(WE)                                                       WAVS0940
      CT=COS(WE)                                                       WAVS0950
      DS=ZBAR+ZS+YLSW*PHIBAR                                           WAVS0960
      DSR=DS-(XREF-XS)*THEBAR                                          WAVS0970
      ID=1.+(DSR*12.-SDS)/DDS                                          WAVS0980
      ID=MAXO(MINO(ID,NDS),1)                                          WAVS0990
      DDSR=(DSR*12.-DDSR)/DDS                                          WAVS1000
      ID1=MINO(ID+1,NDS)                                               WAVS1010
      DSS=DS-XSS*THEBAR                                                WAVS1020
      ZCR1=(SIGN(1.,DSS)+1.)/2.                                        WAVS1030
      IDSS=1.5+(DSS-S2B)/DBB                                           WAVS1040
      IDSS=MINO(N8B,IDSS)                                              WAVS1050
      BS=BB(IDSS)                                                      WAVS1060
      CK=BB*COS(XWK*COGAM*XSS)                                         WAVS1070
      A33S=(RHO*PI*BS**2)/8.                                          WAVS1080
      SK= SIN(XWK*COGAM*XSS)                                           WAVS1090
      A22S=(RHO*.4*PI*DSS**2)/2.                                       WAVS1100
```

```
C     INTERPOLATION OF WAVE TABLES                                    WAVS1140
      A42S=0.0                                                        WAVS1150
      K=1                                                             WAVS1160
      L=IAA                                                           WAVS1170
41    CONTINUE                                                        WAVS1180
      BC0=AC0(L,ID,IP)                                                WAVS1190
      BC00=AC00(L,ID,IP)                                              WAVS1200
      BC1=AC1(L,ID,IP)                                                WAVS1210
      BC2=AC2(L,ID,IP)                                                WAVS1220
      BC3=AC3(L,ID,IP)                                                WAVS1230
      BC4=AC4(L,ID,IP)                                                WAVS1240
      BC5=AC5(L,ID,IP)                                                WAVS1250
      BC7=AC7(L,ID,IP)                                                WAVS1260
      BC8=AC8(L,ID,IP)                                                WAVS1270
      BS00=AS00(L,ID,IP)                                              WAVS1280
      BS1=AS1(L,ID,IP)                                                WAVS1290
      BS2=AS2(L,ID,IP)                                                WAVS1300
      BS3=AS3(L,ID,IP)                                                WAVS1310
      BS4=AS4(L,ID,IP)                                                WAVS1320
      BS5=AS5(L,ID,IP)                                                WAVS1330
      BS6=AS6(L,ID,IP)                                                WAVS1340
      BS7=AS7(L,ID,IP)                                                WAVS1350
      BS8=AS8(L,ID,IP)                                                WAVS1360
      WC0(K)=BC0+DID*(AC0(L,ID1,IP)-ACO(L,ID1,IP1)-BC0)              WAVS1390
     1       +DIP*(AC0(L,ID,IP1)-BC0)                                 WAVS1400
      WC00(K)=BC00+DID*(AC00(L,ID1,IP)-AC00(L,ID1,IP1)-BC00)         WAVS1410
     1       +DIP*(AC00(L,ID,IP1)-BC00)                               WAVS1420
      WC1(K)=BC1+DID*(AC1(L,ID1,IP)-AC1(L,ID1,IP1)-BC1)              WAVS1430
     1       +DIP*(AC1(L,ID,IP1)-BC1)                                 WAVS1440
      WC2(K)=BC2+DID*(AC2(L,ID1,IP)-AC2(L,ID1,IP1)-BC2)              WAVS1450
     1       +DIP*(AC2(L,ID,IP1)-BC2)                                 WAVS1460
      WC3(K)=BC3+DID*(AC3(L,ID1,IP)-AC3(L,ID1,IP1)-BC3)              WAVS1470
     1       +DIP*(AC3(L,ID,IP1)-BC3)                                 WAVS1480
      WC4(K)=BC4+DID*(AC4(L,ID1,IP)-AC4(L,ID1,IP1)-BC4)              WAVS1490
     1       +DIP*(AC4(L,ID,IP1)-BC4)                                 WAVS1500
      WC5(K)=BC5+DID*(AC5(L,ID1,IP)-AC5(L,ID1,IP1)-BC5)              WAVS1510
     1       +DIP*(AC5(L,ID,IP1)-BC5)                                 WAVS1520
      WC6(K)=BC6+DID*(AC6(L,ID1,IP)-AC6(L,ID1,IP1)-BC6)              WAVS1530
     1       +DIP*(AC6(L,ID,IP1)-BC6)                                 WAVS1540
      WC7(K)=BC7+DID*(AC7(L,ID1,IP)-AC7(L,ID1,IP1)-BC7)              WAVS1550
     1       +DIP*(AC7(L,ID,IP1)-BC7)                                 WAVS1560
      WC8(K)=BC8+DID*(AC8(L,ID1,IP)-AC8(L,ID1,IP1)-BC8)              WAVS1570
     1       +DIP*(AC8(L,ID,IP1)-BC8)                                 WAVS1580
      WS0(K)=BS0+DID*(AS0(L,ID1,IP)-AS0(L,ID1,IP1)-BS0)              WAVS1590
     1       +DIP*(AS0(L,ID,IP1)-BS0)                                 WAVS1600
      WS00(K)=BS00+DID*(AS00(L,ID1,IP)-AS00(L,ID1,IP1)-BS00)         WAVS1610
     1       +DIP*(AS00(L,ID,IP1)-BS00)
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      1  +DID(K)*(ASOO(L,ID1,IP1)-ASOO(L,ID,IP1)+BSOO))            WAVS1620
      1  WS1(K)=BS1+DID1(L,ID1,IP1)-AS1(L,ID,IP1)-BS1)             WAVS1630
      1  +DID1(K)*(AS1(L,ID1,IP1)-AS1(L,ID,IP1)+BS1)              WAVS1640
      1  WS2(K)=BS2+DID2(L,ID1,IP1)-AS2(L,ID,IP1)-BS2)            WAVS1650
      1  +DID2(K)*(AS2(L,ID1,IP1)-AS2(L,ID,IP1)+BS2)             WAVS1660
      1  WS3(K)=BS3+DID3(L,ID1,IP1)-AS3(L,ID,IP1)-BS3)           WAVS1670
      1  +DID3(K)*(AS3(L,ID1,IP1)-AS3(L,ID,IP1)+BS3)            WAVS1680
      1  WS4(K)=BS4+DID4(L,ID1,IP1)-AS4(L,ID,IP1)-BS4)          WAVS1690
      1  +DID4(K)*(AS4(L,ID1,IP1)-AS4(L,ID,IP1)+BS4)           WAVS1700
      1  WS5(K)=BS5+DID5(L,ID1,IP1)-AS5(L,ID,IP1)-BS5)         WAVS1710
      1  +DID5(K)*(AS5(L,ID1,IP1)-AS5(L,ID,IP1)+BS5)          WAVS1720
      1  WS6(K)=BS6+DID6(L,ID1,IP1)-AS6(L,ID,IP1)-BS6)        WAVS1730
      1  +DID6(K)*(AS6(L,ID1,IP1)-AS6(L,ID,IP1)+BS6)         WAVS1740
      1  WS7(K)=BS7+DID7(L,ID1,IP1)-AS7(L,ID,IP1)-BS7)       WAVS1750
      1  +DID7(K)*(AS7(L,ID1,IP1)-AS7(L,ID,IP1)+BS7)        WAVS1760
      1  WS8(K)=BS8+DID8(L,ID1,IP1)-AS8(L,ID,IP1)-BS8)      WAVS1770
      1  +DID8(K)*(AS8(L,ID1,IP1)-AS8(L,ID,IP1)+BS8)       WAVS1780
         IF(K .EQ. 2) GOTO 42                              WAVS1790
         K=2                                               WAVS1800
         L=IAA1                                            WAVS1810
         GOTO 41                                           WAVS1820
      42 WC00=(WCOO)*(DIA(1))*(WC00)*(DIA(1))*SALP         WAVS1830
         WC01=(WC01)*(DIA(2))*(WC01)*(DIA(1))*SALP         WAVS1840
         WC02=(WC2)*(DIA(2))*(WC2)*(DIA(1))*SALP           WAVS1850
         WC03=(WC3)*(DIA(2))*(WC3)*(DIA(1))*SALP           WAVS1860
         WC04=(WC4)*(DIA(2))*(WC4)*(DIA(1))*SALP           WAVS1870
         WC05=(WC5)*(DIA(2))*(WC5)*(DIA(1))*SALP           WAVS1880
         WC06=(WC6)*(DIA(2))*(WC6)*(DIA(1))*SALP           WAVS1890
         WC07=(WC7)*(DIA(2))*(WC7)*(DIA(1))*SALP           WAVS1900
         WC08=(WC8)*(DIA(2))*(WC8)*(DIA(1))*SALP           WAVS1910
         WS00=(WS00)*(DIA(2))*(WS00)*(DIA(1))*SALP         WAVS1920
         WS01=(WS1)*(DIA(2))*(WS1)*(DIA(1))*SALP           WAVS1930
         WS02=(WS2)*(DIA(2))*(WS2)*(DIA(1))*SALP           WAVS1940
         WS03=(WS3)*(DIA(2))*(WS3)*(DIA(1))*SALP           WAVS1950
         WS04=(WS4)*(DIA(2))*(WS4)*(DIA(1))*SALP           WAVS1960
         WS05=(WS5)*(DIA(2))*(WS5)*(DIA(1))*SALP           WAVS1970
         WS06=(WS6)*(DIA(2))*(WS6)*(DIA(1))*SALP           WAVS1980
         WS07=(WS7)*(DIA(2))*(WS7)*(DIA(1))*SALP           WAVS1990
         WS08=(WS8)*(DIA(2))*(WS8)*(DIA(1))*SALP           WAVS2000
C     SHIFT MOMENT CENTER FROM XREF TO C.G.                WAVS2010
         BC00=BC00-(XS-XREF)*BC0                           WAVS2020
         BC01=BC1-(XS-XREF)*BC1                            WAVS2030
         BC04=BC4-(XS-XREF)*BC2                            WAVS2040
         BC06=BC6-(XS-XREF)*BC5                            WAVS2050
         BS00=BS00-(XS-XREF)*BS0                           WAVS2060
         BS3=BS3-(XS-XREF)*BS1                             WAVS2070
                                                           WAVS2080
                                                           WAVS2090
```

```
      BS4 = BS4 -(XS-XREF)*BS2                                       WAVS2100
      BS6 = BS6 -(XS-XREF)*BS5                                       WAVS2110
C     CALCULATE WAVE FORCES AND MOMENTS                             WAVS2120
      FZC=BS1-XWK*G*(BS2+BSO)-U*OM1*(-A33S*CK-AL*BS2)               WAVS2130
      FZS=BC1-XWK*G*(BC2+BCO)+U*OM1*(-A33S*SK+AL*BC2)               WAVS2140
      FMC=BS3-XWK*G*(BS4+BSOO)-U*OM1*(-A33S*XSS*CK-BC2-AL*BS4)      WAVS2150
      FMS=BC3-XWK*G*(BC4+BCOO)+U*OM1*(-A33S*XSS*SK-BS2+AL*BC4)      WAVS2160
      FYC=-XWK*G*(BC5+BCO)-U*OM1*(-A22S*CK+AL*BC5)                 WAVS2170
      FYS=-XWK*G*(BS5+BSO)-U*OM1*(-A22S*SK-BS5+AL*BS5)             WAVS2180
      FNC=-XWK*G*(BC6+BCOO)-U*OM1*(-A22S*XSS*CK-BC5+AL*BC6)        WAVS2190
      FNS=-XWK*G*(BS6+BSOO)-U*OM1*(-A22S*XSS*SK-BS5+AL*BC6)        WAVS2200
      FKC=XWK*G*(BC7-BC8)-U*OM1*(-A42S*SK+AL*BC8)                  WAVS2210
      FKS=-XWK*G*(BS7-BS8)+U*OM1*(-A42S*CK-AL*BS8)                 WAVS2220
      FZW(J)=FZW(J)-AA*(FZC*CT+FZS*ST)                             WAVS2230
      FMW(J)=FMW(J)-AA*(FMC*CT+FMS*ST)*SIGAM                       WAVS2240
      FYW(J)=FYW(J)-AA*(FYC*CT+FYS*ST)*SIGAM                       WAVS2250
      FNW(J)=FNW(J)-AA*(FNC*CT+FNS*ST)*SIGAM                       WAVS2260
      FKW(J)=FKW(J)-AA*(FKC*CT+FKS*ST)*SIGAM                       WAVS2270
      FXW(J)=FXW(J)-2.*AA*RHO*G*BS*DSS*SK*CT                       WAVS2280
   40 CONTINUE                                                     WAVS2290
      IF(IMT.EQ.2) GO TO 100                                       WAVS2300
C     WAVE ELEVATION AROUND THE SIDEWALLS AND SEALS               WAVS2310
      DO 20 J=1,4                                                  WAVS2320
      N=NSTA(J)                                                    WAVS2330
      DO 20 K=1,N                                                  WAVS2340
      ETA(J,K)=ETACG+AA*SIN(XWK*(- XX(J,K)*COGAM-YY(J,K)*SIGAM)+FT)*AA  WAVS2350
      ETACG=ETACG+AA*SIN(FT)                                       WAVS2360
   20 CONTINUE                                                     WAVS2370
      N=NSTA(3)                                                    WAVS2380
      DO 25 J=1,N                                                  WAVS2390
      ARG=AA*COS(XWK*(-XX(3,J)*COGAM)+FT)                          WAVS2400
      DETABK(J)=DETABX(J)-XWK*COGAM*ARG                            WAVS2410
   25 CONTINUE                                                     WAVS2420
      N=NSTA(4)                                                    WAVS2430
      DO 30 J=1,N                                                  WAVS2440
      ARG=AA*COS(XWK*(-XX(4,J)*COGAM)+FT)                          WAVS2450
      DETADX(J)=DETADX(J)-XWK*COGAM*ARG                            WAVS2460
   30 CONTINUE                                                     WAVS2470
C     WAVE PUMPING                                                 WAVS2480
      X1=XWK*XLBW*COGAM/2.                                         WAVS2490
      X2=XWK*XGBW*SIGAM/2.                                         WAVS2500
      FTT=FT-XWK*XCP*COGAM                                         WAVS2510
      DVOLW=DVOLW+AA*ABW*T2(X1)*T2(X2)*SIN(FTT)                    WAVS2520
  100 CONTINUE                                                     WAVS2530
      IF(IMT.EQ.2) RETURN                                          WAVS2540
C     TOTAL WAVE FORCES AND MOMENTS                               WAVS2550
      FXAV=FXW(1)+FX4(2)                                           WAVS2560
      FYAV=FYW(1)+FYW(2)                                           WAVS2570
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      FZWAV=FZW(1)+FZW(2)                                                  WAVS2580
      FKWAV=FKW(1)+FKW(2)+(FZW(2)-FZW(1))*YSW                              WAVS2590
      FMWAV=FMW(1)+FMW(2)-FXWAV*ZBAR                    +FYWAV*ZBAR        WAVS2600
      FNWAV=FNW(1)+FNW(2)+(FXW(1)-FXW(2))*YSW                              WAVS2610
      IF (IWAVES.NE.ON) RETURN                                            WAVS2620
      WRITE(6,200)   ((ETA(I,J),J=1,11),I=1,4),ETACG,DVOLW                WAVS2630
     1 ,FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                               WAVS2640
  200 FORMAT(/10X,5HWAVES /63H WAVE ELEVATIONS AT CRAFT STATIONS RELATIV  WAVS2650
     1E TO CALM WATER (FT.) /14H PORT SIDEWALL /11F10.5/14H STBD SIDEWAL  WAVS2660
     2L /11F10.5/9H BOW SEAL /11F10.5/11H STERN SEAL /11F10.5/25H WAVE E  WAVS2670
     3LEVATION AT C.G. = F10.5,10X,43HPLENUM VOLUME LOST DUE TO WAVES (C  WAVS2680
     4U. FT.) = F15.5/10X,23HWAVES FX,FY,FZ,FK,FM,FN /6E15.4)             WAVS2690
      RETURN                                                              WAVS2700
      END                                                                 WAVS2710
```

SAMPLE INPUT DATA DECK

```
00101  0.0        10.0      .01       .05       .00001    .0000001  .0001     .00001    .000000001.000000001
00102
00103
1002        .0002     .00001
.0001       .0001
.0001
.0104            1
00105  6050.0     10.05     2.54      2370.0    9320.0    10580.0   -2800.
00201  -11.37     21.9      5.7       5.0       24.5
00301  5.37       1.875     1.28      1.28
00401  3.74       10.9      26.0      0.90      63.4      1.0       4.06
00501  23.44                1.0       1.375     63.4      4.06      0.1
00701  20.0                 17.2      10.0      20.0      10.40     1.915
00702  -11.275    5.55      -0.604    275.0     0.0       .68
00801  -11.125    5.55      -0.208    1.21      2.15      .167
00901  20.0       10.0
01001  19.6       2.0        11.5      22.33
01201  230.                  .01
01601  230.                  .01
01602  4.1
01603
013    4.1 DEG RIGHT RUDDER TURN, 19.6 KTS
01901  2615.0     24.0       1.
01901  2.0        9.0        14.00     18.5      22.0      25.0      26.0
27.5        4.0       31.0       33.00     34.0      34.5      35.0      35.5
143.75      29.5      31.25      40.0      41.0      42.0      43.0      44.0
93.75       37.5      131.25     125.0     118.75    112.5     106.25    100.0
43.75       37.5      31.25      25.0      68.75     62.5      56.25     50.0
                                            18.75     12.5      6.25      0.0
01902  2615.0     24.0       1.
01903  2.0        9.0        14.00     18.5      22.0      25.0      26.0
27.5        4.0       31.0       33.00     34.0      34.5      35.0      35.5
143.75      29.5      131.25     41.0      42.0      43.0      44.0
93.75       37.5      131.25     125.0     118.75    112.5     106.25    100.0
43.75       37.5      31.25      75.0      68.75     62.5      56.25     50.0
                                            18.75     12.5      6.25      0.0
```

```
01903 1.0       2615.0       24.0         1.
0.0      4.0      14.0      18.5      22.0      25.0      26.0
27.5     29.5     31.0      34.0      34.5      35.0      35.5
36.0     37.0     38.0      41.0      42.0      43.0      44.0
143.75   137.5    131.25    118.75    112.5     106.25    100.0
93.75    87.5     81.25     68.75     62.5      56.25     50.0
43.75    37.5     31.25     18.75     12.5      6.25      0.0
020
0003030506 0709
00213 05 041011
0104
022
0700
0103010501060107010901100111
2.1 DEG RIGHT RUDDER TURN, 19.6 KTS
013
014
```

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